Rules and Regulations

for the

Classification and Construction of

SMALL CRAFTS

PHOENIX REGISTER OF SHIPPING 16, 2as Merarchias str., Piraeus 18535, Greece

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PHOENIX REGISTER OF SHIPPING

Part 1 – Classification

Part 2 - Materials

Part 3 - Hull Construction and Equipment

Part 4 - Specialized Vessels

Part 5 - Machinery

Part 6 - Electrical Installations

Part 7 - Fire Protection, Detection and Extinction

Part 8 – Control Engineering Systems

PHOENIX REGISTER OF SHIPPING

Part 1 – Classification

June 2019

CHAPTER 1 GENERAL CONDITIONS

SECTION 1 General conditions

1.1 Scope of classifications

1.1.1 Phoenix Register of Shipping

PHOENIX REGISTER OF SHIPPING hereinafter referred to also as "**PH.R.S.**", or as the Society, is a nongovernmental technical organization, and its activities include the classification of vessels, crafts and floating units.

1.1.2 Expression of Technical Consideration

PH.R.S. consideration is clearly reflected by the issue of documents / certificates based to the Rules and Regulations of the Society.

It remains at owner's responsibility the maintenance of the vessel, craft or floating unit at a seaworthy condition till the next scheduled survey as required by the Rules and the Regulations.

1.1.3 Documents

The Society develops further Rules and other documented procedures, publishes Register on annual base and issue Certificates, Reports and Attestations as result of its services. The interpretation of all the previous documents remains to the exclusive right of PH.R.S. and any reference to the application of these documents is permitted only with the prior consent of PH.R.S. Administration.

1.1.4 Delegation by flag administrations

Upon delegation by Flag Administrations, PH.R.S., may participate in the application, development and interpretation of National or International Regulations and standards. Intervention of the Society shall be requested with a written application and pre-suppose the acceptance, without reservation of the present general conditions.

1.2 Application-Terms

1.2.1 Intervention of the Society shall be requested with a written application and pre-suppose the acceptance, without reservation of the present general conditions.

1.2.2 This part of the Rules is concerning ships under construction and ships in service as well.

1.3 Definitions

The following technical definitions are applicable within these Rules and Regulations:

1.3.1 Close-up examination

Close-up examination consists to a close thorough visual examination of structure or machinery, by use of several testing means, (hammer, magnifying glass, spot light etc.), if deemed as necessary.

1.3.2 Overall examination

OVERALL EXAMINATION consists to an examination intended to report on the overall condition of structure or machinery and determine the extent of additional close-up examinations.

1.3.3 External examination (in general)

EXTERNAL EXAMINATION (IN GENERAL), consists to a visual inspection of structure or machinery, without dismantling, in order to provide sufficient assessment of their satisfactory condition and to determine, where necessary, the need for further particular examination.

1.3.4 Internal examination

INTERNAL EXAMINATION consists to a visual inspection of structure or machinery, in dismantled condition (either partially or wholly). The same definition applies, also, for the visual examination of a specific arrangement, (as boilers, pressure vessels, tanks etc.), from the inside in order to provide sufficient assessment of their satisfactory condition and to determine, where necessary, the need for further particular examination (close-up survey).

1.3.5 Operation test

OPERATION TEST consists to an external examination of machinery or appliance under usual running conditions, combined with the measurement of essential operating parameters.

1.3.6 Non destructive strength test

NON DESTRUCTIVE STRENGTH TEST consists to a pre-arranged procedure aimed to verify that the tested item can reach its normal working parameters without damage. Actually means that the tested item can suffer the applied overload testing.

1.3.7 Destructive strength test

DESTRUCTIVE STRENGTH TEST consists to the destruction of tested item by use of special equipment, recording the parameters until the damage to be effected.

1.3.8 Tightness test

TIGHTNESS TEST consists to the verification that the tested item does not appears signs of liquid or gas penetration.

CHAPTER 2 CLASSIFICATION

SECTION 1 General

1.1 The rules

1.1.1 The present Rules and Regulations for the Construction and Classification of Small Craft, hereinafter referred to as the Rules, are the basis for the Classification of the aforementioned vessels by PH.R.S.

1.2 Definitions

1.2.1 Yachts are considered to be pleasure craft not engaged in trade. Pleasure craft chartered are considered as yachts.

1.2.2 Small craft are considered to be either yachts or special purpose service craft not greater than 60 meters in length, generally not falling within the scope of the International Conventions. In the present Rules and Regulations the terms ship and small craft are equivalent.

1.2.3 Froude number is called the non-dimensional number given by the formula:

$$Fr = \frac{V}{\sqrt{g\,L}}$$

Where:

V= The maximum velocity of the craft, in m/sec.

L= The length between perpendiculars of the craft, in m.

g= The gravity acceleration, which is to be taken 9,80665 m/sec^2.

1.2.4

a. Displacement craft is considered to be craft with $Fr \leq 0{,}5$.

b. Planning craft is considered to be craft with $Fr > 0{,}5$.

c. Light displacement craft is a craft with displacement not exceeding: $\Delta = 0{,}04\ (L \cdot B)^{1{,}5}$

1.2.5 Service craft is any craft within the scope of the Rules other than a yacht.

1.3 Application

1.3.1 The present Rules and Regulations are applied to the following types of vessels:

a. Displacement glass reinforced plastic craft up to 60 m in length.

b. Planning glass reinforced plastic craft up to 36 m in length.

c. Vessels of steel or aluminum construction up to 60 m in length.

d. Multi-hull craft

e. Light displacement craft

f. Wooden vessels up to 36 m in length.

1.4 Classification symbols

1.4.1 Classification symbols comprise the construction mark, the Society's logo, the division number, the rating letter, the equipment symbol and the machinery installation symbol. This notation is to be grouped on Class Certificate and in the Register Book.

1.4.2 **Construction mark:** ✠ is assigned to a ship, craft or floating unit, which was built under the attendance and in fully compliance with Society's Rules and Regulations. For ships, which were built under the attendance of other recognized classification society, this mark is omitted.

1.4.3 **Society's logo: PH.R.S.** is assigned to all ships, crafts or floating units which are classed by the Society.

1.4.4 **Division number:** this is represented by the figures **100** or **90** where division **100** is granted to ships which their construction and scantlings of the hull and other essential components (except machinery) are intended for seagoing service (unrestricted service). Division **90** is granted to ships which their construction or scantlings (except machinery) are not intended for seagoing service (restricted service).

1.4.5 **Rating letter:** this is represented by the letter **A** or **B**. Letter **A** is assigned to these ships which considered in satisfactory and efficient condition for their intended service and they are following the periodical and annual surveys schedule as described in details in the Section 4 of Chapter 1 of Rules and Regulations for the classification and construction of steel ships. Letter **B** is assigned to these ships which are under special consideration due of their age or condition and their periodicity of survey may be shorter than those normally apply to ships being assigned the rating letter **A**.

1.4.6 **The equipment symbol**: this is represented by the figure **1** placed after the rating letter and it is indicate that ship's anchoring and mooring equipment is in accordance with the requirements of the present Rules and Regulations. In case that the above criteria is not satisfied but equipment considered as adequate for the intended service then symbol **2** may be granted. When the Society does not express its opinion on the equipment in regard to the specific operating conditions of the ship the equipment symbol may be omitted.

1.4.7 **The Machinery installation symbol:** this is represented by the symbol **IMS** and it is placed after the equipment symbol and express that ship's machinery, essential auxiliary machinery, electrical installations and boilers (if any) meet the requirements of the present Rules and the Regulations.

1.4.8 The **planning craft notation** symbol **PC** will be assigned to all craft the design of which is in compliance with the relevant requirements of the present Rules.

1.4.9 Example of Class Notation: ✠ **PH.R.S. 100A1, IMS** or **PH.R.S. 100A1**.

1.4.10 For more classification details see "Rules and Regulation for the classification and construction of Steel Ships".

1.5 Service notations

1.5.1 Service restriction notations for small craft will generally be assigned in one of the following forms, but this does not preclude Owners or Builders requesting special consideration for other forms in unusual cases:

a. Protected waters service (PWS)

Service in sheltered water adjacent to sand banks, reefs, breakwaters or other coastal features and in sheltered water between islands.

b. Extended protected waters service (EPWS)

Service in protected waters and also for short distances (generally less than 15 nautical miles) beyond protected waters in “reasonable weather”.

c. Specified coastal service (CS)

Service along a coast, the geographical limits of which are defined in the Register Book, and for a distance out to sea generally less than 21 nautical miles, unless some other distance is specified for “coastal service” by the Administration with which the craft is registered, or by the Administration of the coast off which it is operating as applicable, e.g. “Greek Coastal service”.

d. Specified route service

Service between two or more ports or other geographical features which will be indicated in the Register Book, e.g. “Piraeus to Andros service”.

e. Specific operating area service

Service within one or more geographical area(s) which will be indicated in the Register Book, e.g. “Service within the Saronic Gulf”.

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PHOENIX REGISTER OF SHIPPING

Part 2 - Materials

June 2019

CHAPTER 1 STEEL

SECTION 1 General requirements

1.1 General

1.1.1 The requirements specified in the “Rules and Regulations for the Classification and Construction of Steel Ships”, Part 2, are to be complied with, to the extent applicable.

CHAPTER 2 ALUMINIUM ALLOYS

SECTION 1 Material properties

1.1 Scope

1.1.1 The requirements specified in the “Rules and Regulations for the Classification and Construction of Steel Ships”, Part 2, Chapter 7, are to be complied with, to the extent applicable.

1.2 Manufacture and condition of supply

1.2.1 The requirements specified in the “Rules and Regulations for the Classification and Construction of Steel Ships”, Part 2, Chapter 7, are to be complied with, to the extent applicable.

1.3 Freedom from defects and dimensional tolerances

1.3.1 The requirements specified in the “Rules and Regulations for the Classification and Construction of Steel Ships”, Part 2, Chapter 7, are to be complied with, to the extent applicable.

1.4 Chemical composition

1.4.1 The requirements specified in the “Rules and Regulations for the Classification and Construction of Steel Ships”, Part 2, Chapter 7, are to be complied with, to the extent applicable.

1.5 Heat treatment

1.5.1 Plates, bars and sections are to be supplied in the following circumstances:

- 5083-0 annealed
- 5083-F as fabricated
- 5083-H321 strain hardened and stabilized
- 5086-0 annealed
- 5086-F as fabricated
- 5086-H321 strain hardened and stabilized
- 6061-T6 solution heat treated and artificially aged
- 6082-T6 solution heat treated and artificially aged

1.6 Mechanical properties and tests

1.6.1 The requirements specified in the “Rules and Regulations for the Classification and Construction of Steel Ships”, Part 2, Chapter 7, are to be complied with, to the extent applicable.

1.7 Weldability

1.7.1 All materials must be capable of being welded by established methods, preferably by gas-shielded welding processes.

1.8 Test of surface finish and dimensions

1.8.1 All pieces shall be inspected by the manufacturer with regard to their surface finish and dimensions. The pieces shall then be presented to the Surveyor for final inspection.

1.9 Non-destructive tests

1.9.1 Where called for in the purchase order or required by the specification, the manufacturer must subject the products to a suitable non-destructive test. Where necessary, agreements shall be reached regarding the method of testing and the permitted limits for indications of defects. Furthermore, the Surveyor may require that a test be performed if there are reasons to doubt that the products are free from defects.

1.10 Marking

1.10.1 The requirements specified in the "Rules and Regulations for the Classification and Construction of Steel Ships", Part 2, Chapter 7, are to be complied with, to the extent applicable.

1.11 Certification

1.11.1 The requirements specified in the "Rules and Regulations for the Classification and Construction of Steel Ships", Part 2, Chapter 7, are to be complied with, to the extent applicable.

SECTION 2 Aluminium weldings and welding procedures

2.1 Application

2.1.1 The requirements of this Section are applicable to mono-hull and multi-hull craft of aluminium construction.

2.1.2 In this Section are included the general requirements for the construction of aluminium craft under the use of two welding processes: the metal inert gas (MIG) and the tungsten inert gas (TIG). Where alternative methods of construction are proposed, additional documentation is to be submitted for consideration by PH.R.S.

2.2 General design principles

2.2.1 Any abrupt change in the general contour of the structure increase the stress level of the adjacent area well above the average stress level. For that reason it is important to eliminate, as far as it is practicable, details such as groove welds, small insert plates and drain holes in the vicinity of significant structural discontinuities. Measures are to be taken to provide as smooth a stress flow in the structural contour as it is possible by using, for instance, connecting brackets.

2.2.2 Where a rigid member terminates abruptly in the middle of a plate panel which is inherently flexible, a point of stress concentration is produced. Such points are to be avoided.

2.2.3 Welds are to be located in a way so as to avoid the creation of high restraints against weld shrinkage, e.g. the welding of small thick insert plates. Therefore the use of small inserts for reinforcement of openings should be avoided.

2.2.4 When designing weld joints, factors concerned with material special characteristics are to be taken into account, such as the reduced strength values of rolled plates in the through thickness direction. Material properties and the specific location of weld joints should be specially considered in order to avoid dangerous phenomena such as lamellar tearing.

2.2.5 The design of welded joints and the sequence of welding should enable residual welding stresses to be kept to a minimum. Welded joints are not to be over-dimensioned.

2.2.6 Weld joints, and especially heavily loaded weld joints, are to be so designed that the most suitable method of testing for defects can be used (radiography, ultrasonic, surface crack inspection) in order that a reliable examination may be carried out.

2.2.7 Welded joints are to be designed to ensure that the proposed weld type and quality can be satisfactorily achieved under the given fabricating conditions.

2.2.8 Where different types of materials are welded and operate in sea water or any other electrolytic medium, i.e. weld joints made between unalloyed and stainless steels in the wear linings of jet rudders and the built-up welds on rudderstocks, attention is to be paid to the increased tendency towards corrosion, especially at the weld, due to the differences in electrochemical potential. Where necessary, the welded joints should be located at points where there is less danger of corrosion (e.g. outside tanks) or special corrosion protection should be provided (e.g. coating or catholic protection).

2.3 Welding consumables

2.3.1 All welding consumables used have to be approved by PH.R.S. or other recognized Classification Society and are to be suitable for the type of joint and grade of material see SECTION 1.

2.3.2 Alloys such as 5083 and 5086 are normally welded using the 5356, 5556 or 5183 consumables and alloys such as 6061 and 6082 are normally welded using the 4043 consumables.

2.3.3 Cast aluminium alloys are not in general to be welded directly to wrought high magnesium alloys unless the welding is carried out in accordance with an agreed procedure.

2.3.4 The distribution, storage and handling of all welding consumables is a very important matter and should be dealt with special care. The aluminium filler metals must be kept in a heated and dry storage place with a relatively uniform temperature. The metal surface should remain clear of condensation during storage and use. Welding studs and bare wire are to be stored in dry places to prevent corrosion.

2.4 Welder qualifications

2.4.1 The welders, should be experienced and well-qualified. The Builders have to keep records of tests and qualifications of each welder, which will be available to the Surveyors, in order to check if the personnel involved in the construction procedure is capable of achieving the required standard of workmanship.

2.5 Documentation to be submitted

2.5.1 The documentation submitted for approval has to indicate clearly details of the welded connections of the main structural members. In addition to this, it is also to include the type, size and disposition of welds.

2.5.2 The following information is to be submitted:

- Grades, tempers and thicknesses of materials to be welded
- Weld throat thickness or leg lengths
- Locations, types of joints and angles of abutting members
- Sequence of welding of assemblies and joining up of assemblies
- Reference to welding procedures to be used

2.6 Butt welding

2.6.1 Butt welding is to be used for plates and section butts. It is mandatory for heavily stressed butts such as those of the bottom, keel, side shell, sheerstrakes and strength deck plating, joints and butts of bulkheads (especially those bulkheads located in areas where vibrations occur).

2.6.2 Wherever possible, joints in girders and sections are not to be located in areas of high bending stress. Joints at the buckling points of the flanges are to be avoided.

2.6.3 The transition between differing component dimensions are to be smooth and gradual. Where the depth of web of girders or sections differs, the flanges or bulbs are to be bevelled and the web slit and expanded or pressed together to equalise the depths of the members. The length of the transition should be at least equal twice the difference in depth.

2.6.4 To provide smooth stress flow, the transition between differing plate thickness is to be gradual. Where the difference in thickness exceeds 3mm, the thicker plate to be welded is to be tapered with a maximum slope $^1/_3$. Differences in thickness of 3mm or less may be accommodated within the weld. In the assembly of two plates of different thickness, the weld must be followed by a backweld.

2.6.5 For the welding on plates or other relatively thin-walled elements, steel castings and forgings must be appropriately tapered or provided with integrally cast or forged welding flanges.

2.6.6 Where stiffening members are going to be attached in plating by continuous fillet welds and to cross completely finished butt welds, the weld reinforcement of butt welds are to be removed and the welds are to be made flush with the adjacent surface. Where butt welding of stiffeners is made prior to continuous fillet welding on plating, the weld reinforcement is also to be removed. Care is to be taken so that the ends of the flush portion not to have notches liable to impair the soundness of the continuous fillet welding. Where these conditions cannot be complied with, a scallop is to be arranged in the web of a stiffening member. A scallop is also used where a butt weld of a stiffener or girder is made after the members have been assembled in place. Scallops shall have a minimum radius of 25mm or twice the plate thickness whichever is the greater. Because an improperly cut scallop is potentially dangerous scallops should be shaped to provide a gentle transition to the adjoining surface.

2.6.7 Where butt welds form a T-junction, the leg of the T is, where practicable, to be completed first including any back run. During the welding operation special attention is to be given to the completion of the weld at the junction, which is to be chipped back to remove crater cracks, etc., before the table is welded.

2.6.8 In Table 2.6.1 and Table 2.6.2 a number of typical joint preparations for TIG and MIG welding is shown respectively.

Table 2.6.1: Typical joint preparations for TIG welding of aluminium alloys

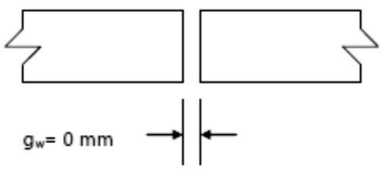
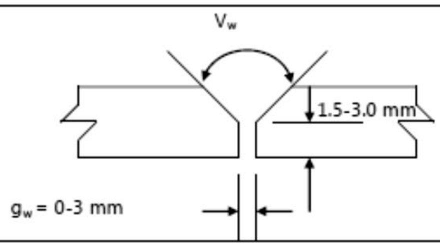
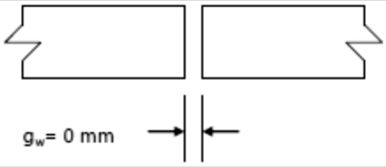
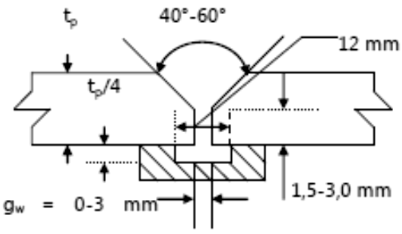
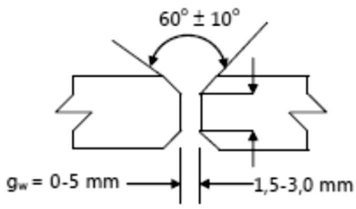
Thickness (m)	Joint design	Welding position/comments
2.5 - 3.0		Flat Horizontal Vertical Overhead
3.0 - 10.0		Flat and Vertical V = 60° Horizontal and Overhead V = 90° - 110°
Symbols and definitions		
g_w = weld gap, mm V_w = weld preparation angle, degrees		

Table 2.6.2: Typical joint preparations for semi-automatic MIG welding

Thickness (m)	Joint design	Welding position/comments
5.0 - 6.5		Flat
7.0 - 15.0		Flat and Vertical Horizontal Vertical Overhead One sided welding with Temporary backing
12.0 - 25.0		All positions

2.7 Fillet welds

2.7.1 T-connections are generally to be made by fillet welds on both sides of the abutting plate, the dimensions and spacing of which are shown in Figure 2.9.1. Where the connection is highly stressed full penetration welding may be required. Where full penetration welding is required, the abutting plate may need to be bevelled.

2.7.2 The throat thickness a of fillet welds is to be determined from:

$$a = t_p \cdot \beta \cdot \frac{d}{s}, \quad mm$$

where:

s= the length of correctly proportioned weld fillet ,clear of end craters, in mm, and is to be 10×plate thickness, tp , or 75 mm whichever is the lesser, but in no case to be taken less than 40 mm.

d= the distance between successive weld fillets, in mm

t_p= plate thickness, in mm, on which weld fillet size is based

β = weld factor

2.7.3 Weld factors are contained in Table 2.10.1

NOTE:

For double continuous fillet welding $\frac{d}{s}$ is to be taken as 1 (see2.10.1).

2.7.4 For ease of welding, it is suggested that the ratio of the web height to the flange breadth be greater than or equal to 1,5 (see Table 2.6.2).

2.7.5 Where an approved automatic deep penetration procedure is used, the weld factors given in Table 2.10.1 may be reduced by 15%.

2.7.6 The leg length of the weld is to be not less than times the specified throat thickness.

2.7.7 The plate thickness t_p to be used in 2.7.2 is generally to be that of the thinner of the two parts being joined. Where the difference in thickness is considerable, the size of fillet will be specially considered.

2.8 Throat thickness limits

2.8.1 The throat thickness limits given in Table 2.11.1 are to be complied with.

2.9 Single sided welding

2.9.1 Where the main welding is carried out from one side only a back sealing run is to be applied to all butt welds, after suitable back gouging, unless the welding process and consumables have been specially approved for one-side welding.

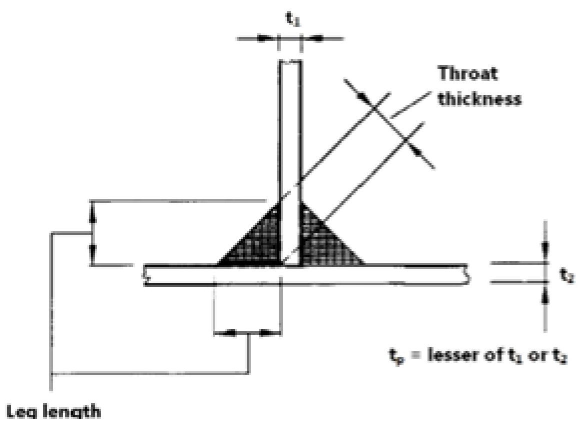
2.9.2 Where internal access for welding is impracticable, backing bars are to be fitted in way of butt and fillet welds, or alternative means of obtaining full penetration welds are to be agreed. Backing bars are to be permanent or temporary.

2.9.3 Permanent backing bars are to be of the same material as the base metal and of thickness not less than the thickness of the plating being joined or 4 mm, whichever is the lesser. The weld is to be thoroughly fused to the backing bar.

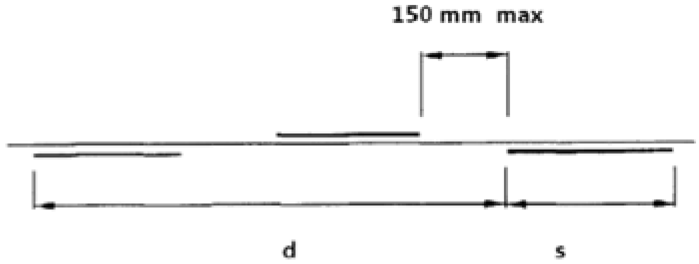
2.9.4 Backing bars are to be continuous for the full length of the weld and joints in the backing bar are to be by full penetration welds, ground smooth.

Figure 2.9.1: Weld types

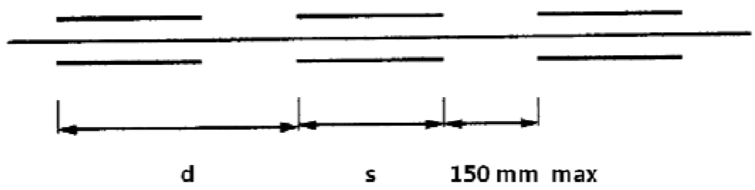
a. Weld fillet dimensions



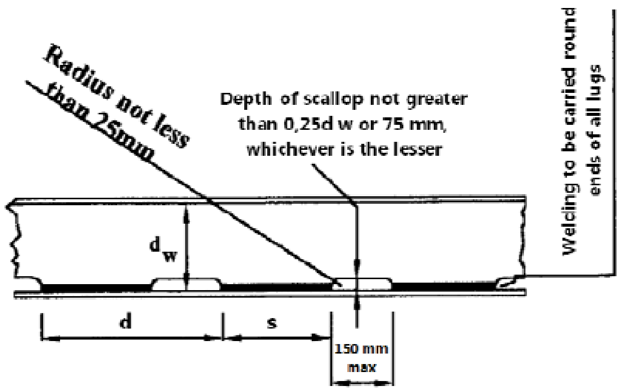
b. Staggered intermittent



c. Chain intermittent



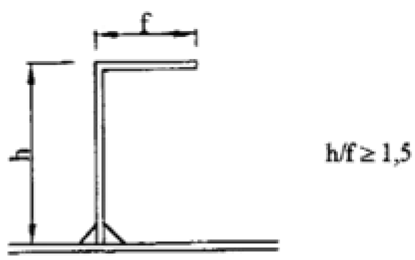
d. Scalloped construction



2.9.5 Temporary backing bars for single sided welding may be austenitic stain less steel, glass tape, ceramic, or anodized aluminum of the same material as the base metal. Backing bars are not to be made of copper to avoid weld contamination and corrosion problems.

2.9.6 Temporary backing bars are to be suitably grooved in way of the weld to ensure full penetration.

Figure 2.9.2: Web height/ flange breadth ratio



2.10 Double continuous welding

2.10.1 Where double continuous fillet welding is proposed the throat thickness is to be in accordance with 2.7.2 taking d/s equal to 1.

2.10.2 Double continuous welding is to be adopted in the following locations and may be used elsewhere if desired:

- Main engine seatings
- Boundaries of tank and watertight compartments.
- Boundaries of weathertight decks and erections, including hatch coamings, companionways and other openings.
- Bottom framing structure of high speed craft in way of machinery and jet rooms paces as appropriate.
- Structure in way of ride control systems, stabilizers, thrusters, bilge keels, foundations and other areas subject to high stresses.
- The side and bottom shell structure in the impact area of high speed motor craft.
- The underside of the cross-deck structure in the impact area of high speed multi-hull craft.
- Stiffening members to plating in way of end connections, and of end brackets to plating in the case of lap connections.
- Face flats to webs of built-up/fabricated stiffening members in way of knees/end brackets and for a distance beyond such knees / end brackets of not less than the web depth of stiffener in way.
- The shell structure in the vicinity of the propeller blades.
- Primary and secondary members to plating in way of end connections, and end brackets to plating in the case of lap connections.

Table 2.10.1: Weld factors (to be continued)

Item	Weld Factor β	Remarks
(1) General application:		except as required below
Watertight plate boundaries	0,34	
Non-tight plate boundaries	0,13	
Longitudinals, frames, beams, and other secondary members to shell, deck or bulkhead plating	0,10 0,13 0,21	 in tanks in way of end connections
Panel stiffeners	0,10	
Overlap welds generally	0,27	
Longitudinals of the flat-bar type to plating		see 2.10.2
(2) Bottom construction :		
Non-tight centre girder : to keel to inner bottom	0,27 0,21	no scallops
Non-tight boundaries of floors, girders and brackets	0,21 0,27	in way of 0,2×span at ends in way of brackets at lower end of main frame
Inner bottom longitudinals, or face flat to floors reverse frames	0,13	
Connection of floors to inner bottom where bulkhead supported on tank top. The supporting floors are to be continuously welded to the inner bottom	0,44	Weld size based on floor thickness Weld material compatible with floor material
(3) Hull framing : Webs of web frames and stringers:		

to shell to face plate	0,16 0,13	
(4) Decks and supporting structure: Weather deck plating to shell Other decks to shell and bulkheads (except where forming tank boundaries) Webs of cantilevers to deck and to shell in way of root bracket Webs of cantilevers to face plate Girder webs to deck clear of end brackets Girder webs to deck in way of end brackets Web of girder to face plate Pillars : fabricated end connections end connections (tubular) Girder web connections and brackets in way of pillar heads and heels	0,44 0,21 0,44 0,21 0,10 0,21 0,10 0,10 0,34 full penetration 0,21	generally continuous Continuous
(5) Bulkheads and tank construction : Plane and corrugated watertight bulkhead boundary at bottom, bilge, inner bottom, deck and connection to shelf plate, where fitted	0,44	Weld size to be based on thickness of bulkhead plating Weld material to be compatible with bulkhead plating material

Item	Weld Factor β	Remarks
Secondary members where acting as pillars Non-watertight pillar bulkhead boundaries Perforated flats and wash bulkhead boundaries Deep tank horizontal boundaries at vertical corrugations	0,13 0,13 0,10 full penetration	
(6) Structure in machinery space : Centre girder to keel and inner bottom Floors to centre girder in way of engine thrust bearers Floors and girders to shell and inner bottom Main engine foundation girders: to top plate to hull structure Floors to main engine Foundation girders Brackets, etc., to main engine foundation girders Transverse and longitudinal framing to shell	0,27 0,27 0,21 deep penetration to depend on design 0,27 0,21 0,13	no scallops to inner bottom edge to be prepared with maximum roote $0{,}33t_p$ deep penetration generally
(7) Superstructures and deckhouses : Connection of external bulkheads to deck Internal bulkheads	0,34 0,21 0,13	1st and 2nd tier erections elsewhere
(8) Steering control systems : Rudder: Fabricated main piece and main piece	0,44	

to side plates and webs		
Slot welds inside plates	0,44	
Remaining construction	0,21	
Fixed and steering nozzles :		
Main structure	0,44	
Elsewhere	0,21	
Fabricated housing and structure of thruster units, stabilizers, etc. :		
Main structure	0,44	
Elsewhere	0,21	
(9) Miscellaneous fittings and equipment :		
Rings for manhole type covers, to deck or bulkhead	0,34	
Frames of shell and weathertight bulkhead doors	0,34	
Stiffening of doors	0,21	
Ventilator, air pipes, etc., Coamings to deck	0,34 0,21	Load Line Position 1 and 2 elsewhere
Ventilator, etc., fittings	0,21	
Scuppers and discharges, to deck	0,44	

Item	Weld Factor β	Remarks
Masts, crane pedestals, etc. to deck	0,44	full penetration welding may be required
Deck machinery seats to deck	0,21	generally
Mooring equipment seats	0,21	generally , but increased or full penetration may be required
Bulwark stays to deck Bulwark attachment to deck	0,21 0,34	
Guard rails, stanchions, etc., to deck	0,34	
Bilge keel ground bars to shell	0,34	continuous fillet weld , minimum throat thickness 4mm
Bilge keels to ground bars	0,21	light continuous or staggered intermittent fillet weld , minimum throat thickness 3mm
Fabricated anchors	full penetration	

2.11 Full penetration welding

2.11.1 Where full penetration welding is required in accordance with 2.6 and 2.7, these are to be made by welding from both sides with the root of the first weld back gouged to sound metal before welding the second side. The weld on the second side may be a sealing run.

2.11.2 Where access to the second side for welding is impracticable, backing bars are to be used in accordance with 2.9.

Table 2.11.1: Throat thickness limits

Item	Throat thickness a mm	
	Minimum	Maximum

(1) Double continuous welding	0,21 t_p	0,44 t_p
(2) Intermittent welding	0,27 t_p	0,44 t_p or 4,5
(3) Overriding minimum		
(a) Continuous welds	2,5	
(b) Intermittent welds		
(i) Plate thickness $t_p \leq 7{,}5$mm		
Hand or automatic welding	3,0	
Automatic deep penetration welding	3,0	
(ii) Plate thickness $t_p \geq 7{,}5$ mm		
Hand or automatic welding	3,25	
Automatic deep penetration welding	3,0	

NOTES:

1) In all cases the limiting maximum value is to be taken as the greatest of the applicable values above.
2) The maximum throat thicknesses shown are intended only as a design limit for the approval of fillet welded joints. Any welding in excess of these limits is to be to the Surveyor's satisfaction.

2.12 Intermittent welding (chain)

2.12.1 Chain intermittent welding may be used, outside of the impact area in the bottom shell or crossdeck structure of high speed craft.

2.13 Intermittent welding (staggered)

2.13.1 Where intermittent welding is used, the welding is to be made continuous round the ends of brackets, lugs, scallops, etc.

2.13.2 Staggered intermittent welding is not to be used in the bottom shell or crossdeck structure of high speed craft.

2.14 Stud welding

2.14.1 Where permanent or temporary studs are to be attached by welding to main structural parts in areas subject to high stress, the proposed location of the studs and the welding procedures adopted are to be to the satisfaction of the Surveyors.

2.15 Slot welding

2.15.1 The connection of plating to internal webs is usually difficult, and the access for welding is not practicable. In such a case the closing plating is to be attached by continuous full penetration welds, or by slot fillet welds to face plates fitted to the webs. Slots are, in general, to have a minimum length of ten times the plating thickness or 75 mm, whichever is the lesser, but in no case to be taken as less than 40 mm, and a minimum width of twice the plating thickness or 15 mm whichever is the greater, with well rounded ends. Slots cut in plating are to have smooth, clean and square edges and the distance between the slots is, in general, not to exceed 150 mm. Slots are not to be filled with welding. Alternative proposals for length, width and spacing of slot welds will be specially considered.

2.16 Lap connections

2.16.1 The connection of plates, which may be subjected to compressive loading or high tensile, is usually not being made by overlaps. In case, however, that plates overlaps are used, the width of the overlap is not, in general, to exceed four times nor be less than three times the thickness of the thinner plate and the joints are to be positioned so as to allow adequate access for completion of sound welds. The faying surfaces of lap joints are to be in close contact and both edges of the overlap are to have continuous fillet welds.

2.17 Connections of primary structure

2.17.1 Connections of primary structure need a full penetration welding.

2.17.2 Special care must be taken of the material lost in the notch, where longitudinals or stiffeners pass through the member, when welding connections to shell, deck or bulkhead. Where the width of notch exceeds 15% of the stiffener spacing, the weld factor is to be multiplied by:

$$\frac{stiffener\ plating\ \cdot 0.85}{length\ of\ web\ plating\ between\ notches}$$

2.17.3 Where direct calculation procedures have been adopted, the weld factors for the 0,2×overall length at the ends of the members will be considered in relation to the calculated loads.

2.18 Primary and secondary member end connection welds

2.18.1 Welding of end connections of primary members is to be such that the area of welding is not less than the cross-sectional area of the member, and the weld factor is to be not less than 0,34 in tanks or 0,27 elsewhere.

2.18.2 The welding of secondary member end connections is to be not less than as required by Table 2.18.1. Where two requirements are given the greater is to be complied with.

2.18.3 The area of weld, Aw, is to be applied to each arm of the bracket or lapped connection.

2.18.4 Where a longitudinal strength member is cut at a primary support and the continuity of strength is provided by brackets, the area of weld is to be not less than the cross-sectional area of the member.

Table 2.18.1: Primary and secondary member end connection welds

Connection	Weld area, A_w, in cm²	Weld factor β
(1) Stiffener welded direct to plating	$0{,}25A_s$ or 6,5 cm², whichever is the greater	0,34
Bracketless connection of stiffeners or stiffener lapped to bracket or bracket lapped to stiffener:		
(a) in dry space	1,2 SM	0,27
(b) in tank	1,4 SM	0,34
(c) main frame to tank side bracket in $0{,}15L_R$ forward	as (a) or (b)	0,34
(3) Bracket welded to face of stiffener and bracket connection to plating		0,34
(4) Stiffener to plating for 0,1×span at ends, or in way of the end bracket if that be greater		0,34

Symbols:

A_S= cross section area of the stiffener, in cm²

A_W= the area of the weld, in cm^2, and is calculated as total length of weld, in cm, × throat thickness, in cm

SM = the section modulus, in cm^3, of the stiffener on which the scantlings of the end bracket are based

NOTE:

For maximum and minimum weld fillet sizes, see Table 2.11.1.

2.19 Weld connection of strength deck plating to sheerstrake

2.19.1 The connection of strength deck plating to sheerstrake is being made by using double continuous fillet welding with a weld factor of 0,44. The welding procedure, including joint preparation, is to be specified and the procedure qualified and approved for individual Builder s.

2.20 Notches and scallops

2.20.1 Notches and scallops are to be kept clear of the toes of brackets, etc. Openings are to be well rounded with smooth edges.

2.20.2 The size and position of the scallops are such, that a satisfactory weld can be made around the ends of openings.

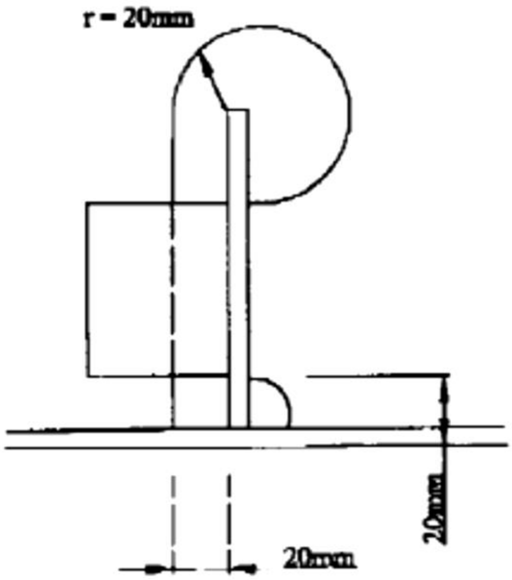
2.21 Watertight collars

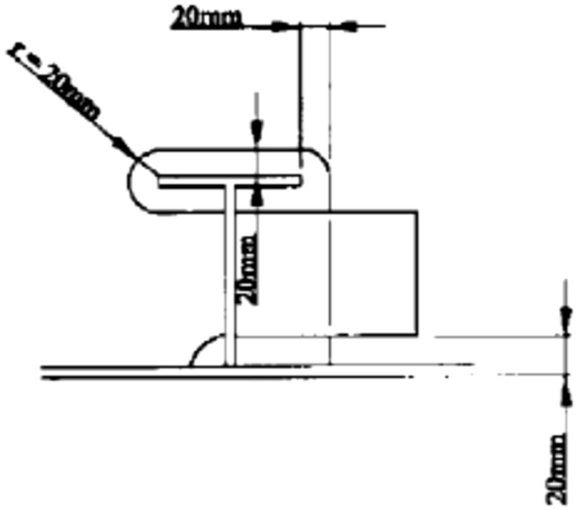
2.21.1 Watertight collars are to be fitted, where stiffeners are continuous through watertight or oil tight boundaries.

2.22 Lug connections

2.22.1 The area of the weld connecting secondary stiffeners to primary structure in the bottoms of the hulls and cross-deck structure in areas subjected to impact pressures is to be not less than the shear area from the Rules. This area is to be obtained by fitting two lugs or by other equivalent arrangements. In Figure 2.22.1 and Figure 2.22.2 are shown some typical lug connections.

Figure 2.22.1: Typical lug connections


r = 20mm
20mm
20mm


20mm
r = 20mm
20mm
20mm

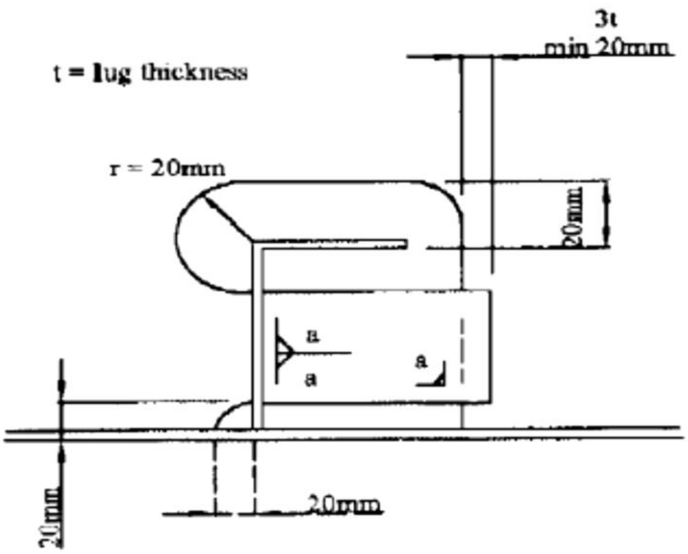
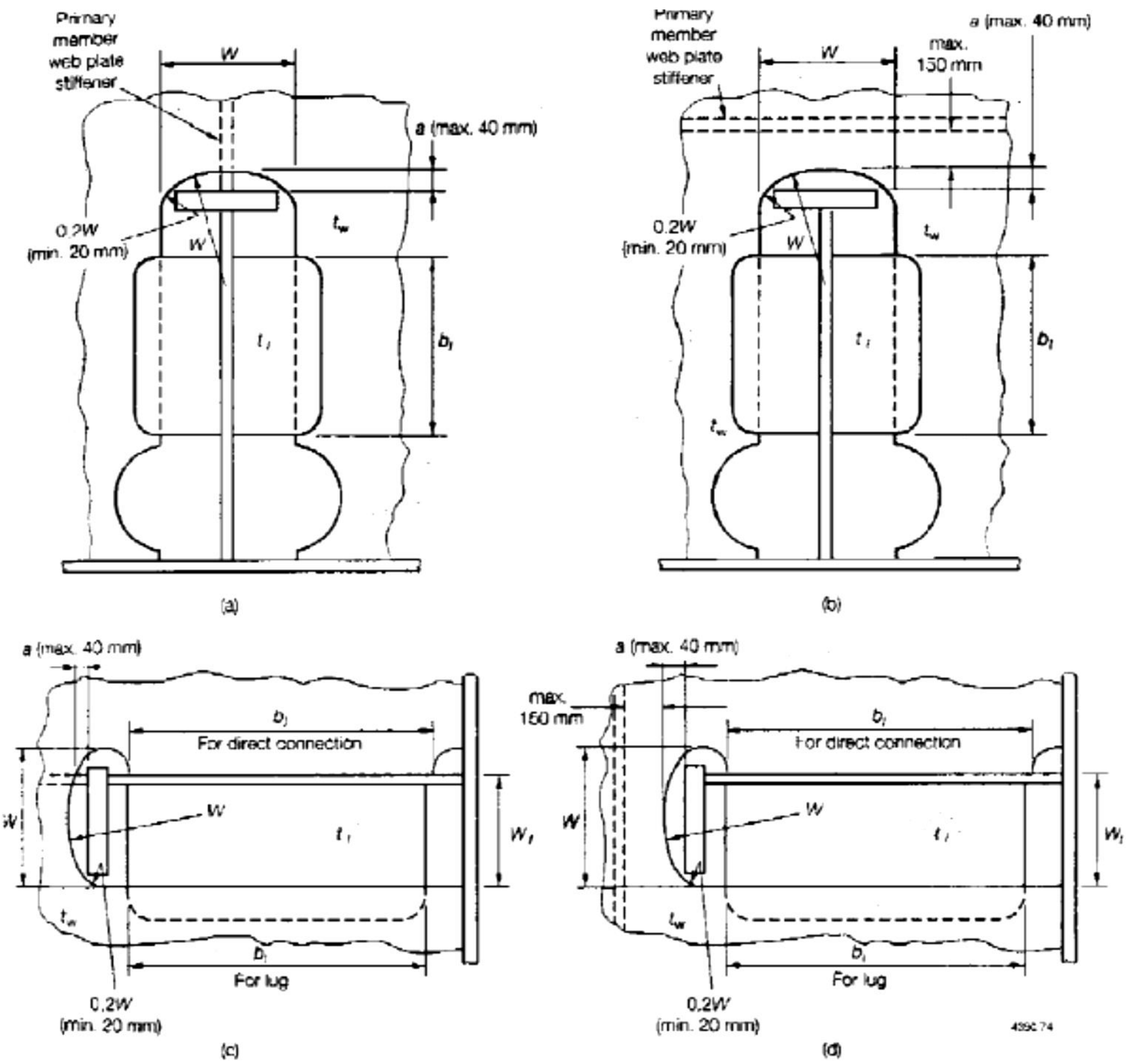

t = lug thickness
3t
min 20mm
r = 20mm
20mm
a
a
a
20mm
20mm

Figure 2.22.2: Cut-outs and connnections



2.22.2 Lugs or tripping brackets are to be fitted where shell longitudinals are continuous through web frames in way of highly stressed areas of the side shell.

2.22.3 Lugs or tripping brackets are also to be fitted where continuous secondary stiffeners are greater than half the depth of the primary stiffeners.

2.23 Insert plates

2.23.1 Where thick insert plates are butt welded to thin plates, the edge of the thick plate may require to be tapered. The slope of the taper is generally not to exceed one in three.

2.23.2 The corners of insert plates are to be suitably radiused.

2.24 Doubler plates

2.24.1 It is usually preferable doubler plates to be avoided in areas, which are easily affected by corrosion and present difficulty in inspection and maintenance.

2.24.2 Where doubler plates are fitted, they are to have well radiused corners and the perimeter is to be continuously welded. Large doubler plates are also to be suitably slot welded, the details of which are to be submitted for consideration.

2.25 Joint preparation

2.25.1 The preparation of plate edges is to be accurate and free from blemishes. All joints are to be properly aligned and closed or adjusted before welding. In case of excessive gaps between surfaces or edges to be joined, the corrective measures adopted are to be to the satisfaction of the Surveyor.

2.25.2 The contraction stresses between the welded parts are to be kept to a minimum. Due to this fact the parts are to be set up and welded very carefully.

2.25.3 Before a manual sealing run is applied to the back of a weld the original root run is to be cut back to sound metal.

2.25.4 In order to remove oxide or adhering films of dirt and filings from the joint edges, an acceptable method should be used, such as scratch brushing, immediately before welding.

2.25.5 In Table 2.6.1 and Table 2.6.2 are shown typical butt joints.

2.26 Triaxial stresses

2.26.1 Poor joint design may result in triaxial stresses, which are considered to be an undesirable case. Detailed joint design can be a great help in order to avoid triaxial stress problems.

2.27 Aluminium / Wood connection

2.27.1 The corrosion of aluminium, caused by its contact to wood in a damp or marine environment, can be minimized by priming and painting the timber. Alternatively the surface of the aluminium in contact with the timber is to be coated with a substantial thickness of a suitable sealant.

2.27.2 Timbers such as western red cedar, oak and chestnut are not, unless well seasoned, to be directly in contact with aluminium.

2.27.3 The following types of timber preservatives should be avoided: copper napthanate, copper-chrome-arsenate, borax-boric acid.

2.28 Aluminium / Steel connection

2.28.1 Provision is made in this Subsection for explosion bonded composite aluminium/steel transition joints used for connecting aluminium structures to steel plating. Such joints are to be used in accordance with the manufacturer's requirements.

2.28.2 Transition joints are to be manufactured by an approved producer in accordance with an approved specification which is to include the maximum temperature allowable at the interface during welding.

2.28.3 The aluminium material is to comply with the requirements of SECTION 1 and the steel is to be of an appropriate grade complying with the relevant PH.R.S. requirements.

2.28.4 Intermediate layers between the aluminium and steel may be used, in which case the material of any such layer is to be specified by the manufacturer and is to be recorded in the approval certificate. Any such intermediate layer is then to be used in all production transition joints.

2.28.5 Bimetallic joints where exposed to seawater or used internally within wet spaces are to be suitably protected to prevent galvanic corrosion.

CHAPTER 3 FRP AND SANDWICH MATERIALS

SECTION 1 General

1.1 General requirements

1.1.1 The requirements of this Chapter are applicable to craft generally constructed of fibre-reinforced plastic, using hand lay-up, mechanical deposition (i.e. spray moulding), contact moulding or vacuum assisted and resin injection techniques. Construction may be either of the single-skin or sandwich type, or a combination of both.

1.1.2 Other materials (i.e. non-FRP materials) are to be of good quality and suitable for the purpose intended. Details of these materials are to be stated on the relevant construction plans. When these materials are attached to, or encapsulated within, the plastic construction, the material is not to affect adversely the cure of the plastic materials.

1.1.3 Where moulding techniques and methods of construction differing from those given in Section 4 are proposed, details are to be submitted for consideration by PH.R.S.

1.1.4 Reinforcement, matrix, fillers and core materials for major hull structural elements are normally to be delivered with a Type Approval Certificate issued by PH.R.S. or other recognized Classification Society. Where the ship is built under special survey, the main raw materials are to be homologated by the Society.

1.1.5 The outer reinforcement ply of the outer hull skin laminate is to be at least 300 g/m² of chopped strand fibers containing as little water-soluble bonding components as possible. Normally, spray roving or powder bound mat should be used. Other material systems giving an equivalent surface protection may also be accepted. Areas inside the hull, expected to be continuously exposed to water submersion (i.e. bilge wells, etc.) shall have a surface lining as required for tanks in 1.1.6.

1.1.6 The insides of tanks shall have a surface lining consisting of at least 600 g/m² reinforcement material as specified in 1.1.5 above, impregnated with Grade-A polyester. If Grade-A polyester is used throughout the tank construction, the reinforcement may be as described in 1.1.5. The surface lining is, as far as practicable, to be laid continuously in the sides and bottom of the tanks.

1.1.7 The construction specifications to be submitted for examination by the Head Office shall in general contain the following data:

- Designation, type and manufacturer of resins, both for laminating resin and gel coat, and of the single reinforcements of laminates as well as of the core material of structures of sandwich construction.
- Brief description of manufacturing procedure of laminates and of the manufacturing environmental conditions.

1.2 Terminology

1.2.1 Basic terminology is as follows:

- For the purposes of these Rules, a ‘**plastic**’ is regarded as an organic substance, which may be thermosetting or thermoplastic and which, in its finished state, may contain reinforcements or additives.
- **Reinforced plastics**: heterogeneous material consisting of a matrix of resin with relevant additives and of fiber reinforcements, produced in the form of laminate formed on a mould.
- **Resins**: unsaturated polyester, vinylester, epoxy or phenolic resins.

- **Reinforcement of reinforced plastics**: fibres in the form of mat, woven roving, cloth or tape. The reinforcement is called:
  of a homogeneous type, when the fibres are of a single material (e.g. glass) in the whole laminate;
  of a mixed type, when the fibres of some layers are of a material other than that of the others;
  of a hybrid type, when the fibres of one or more layers are of two or more different materials.
- **Single-skin laminate**: reinforced plastic material, in general in the form of a flat or curved plate or of sections.
- **Sandwich laminate**: material composed by two single-skin laminates structurally connected to each other by the interposition of a core of light material.

SECTION 2 Raw Materials

2.1 General

2.1.1 Provision is made in this Chapter for the manufacture and testing of plastic materials used in the construction of ships and other marine structures and associated machinery items, which are classed or are intended for classification by PH.R.S.

2.1.2 These materials and products are to be manufactured and surveyed in accordance with the general requirements of SECTION 2, SECTION 3 and SECTION 4.

2.1.3 Raw materials must be type approved by the PH.R.S. or other recognized Classification Society. Minimum requirements for approval of raw materials are given in SECTION 3.

2.1.4 Materials making up the laminates shall have characteristics suitable for the purpose of hull building, at the judgment of the manufacturer. On the basis of the relevant information provided to PH.R.S., this latter may require, at its own judgment, the carrying out of special checks on the laminates.

2.1.5 Details of all the approved and accepted plastic materials are to be submitted by the boat manufacturer with the initial submission of plans. The types and quantities of curing systems reported, are to be those recommended by the resin manufacturer for the approved resin systems. When specifying materials, the manufacturer’s exact type designation, identification and reference numbers are to be quoted. All sandwich core materials are to be of a type acceptable by PH.R.S. and are to be clearly identified, together with any core-bonding adhesive to be used. Fibre contents by weight for each type of reinforcement are to be reported. To the manufacturers of hulls built with type-approved materials, PH.R.S. will issue, upon request, a relevant Statement; on the Certificate of the ship or boat a specific symbol or notation will be entered.

2.2 Resin Systems

2.2.1 Resins used are to be of a type that has been approved by PH.R.S. or other recognized Classification Society, for marine construction purposes. Samples of the resin batches being used in the construction may be taken for limited quality control examination, at the discretion of the Surveyor. Resins other than those utilized for gel coats, are to be unsaturated, general purpose or fire retardant polyesters suitable for marine use, vinylesters or epoxies and are to be catalyzed in strict accordance with manufacturers' recommendations. Resins are to resist abrasion and to have a good stability regarding aging in marine environment and industrial atmosphere.

2.2.2 Isophthalic or orthophthalic polyester may be used. The former is often used for gel coat and outer ply lamination; the latter is of lesser quality but, when properly used, is an effective laminating resin. The polyester is to be suitable for lamination by hand lay-up or spraying. It is to have good wetting properties and is to cure satisfactorily at normal room temperature. Polyester intended for other production methods is to be approved after special consideration.

2.2.3 Epoxy resins cannot form a primary bond with polyester and vinylester resins. Therefore, they can only be used either by themselves or in conjunction with fully cured polyester or vinylester resins.

2.2.4 Phenolic resins, although having superior properties regarding fire resistance, are not generally suitable for structural applications. Where fire retardant additives to the resin system are used, the type and quantity are to be as recommended by the resin manufacturer. The results of independently tested fire retardant and fire-restricting materials are to be submitted. All fire retardant systems are to be used in strict accordance with the resin manufacturer’s recommendation.

2.2.5 The curing procedure for the resin system is to be the one recommended by the resin manufacturer for the particular application, so that the resin will cure in the required time, in accordance with the approved cure schedule. In general, the rate of gelation is to be controlled by the amount of catalyst/accelerator added to the resin. The quantity of catalyst/accelerator is to be kept within the limits stipulated by the manufacturer and, generally, is to be not less than one per cent of the base resin, by weight. During curing, the exothermic temperature is to be kept at a suitable level.

2.2.6 Wax additives are only to be added by the resin manufacturer in accordance with the agreed procedure and tested accordingly.

2.2.7 Where a resin contains an ingredient that can settle within the resin system, it is the Builder’s responsibility to ensure that the resin manufacturer’s recommendations regarding mixing and conditioning are complied with prior to use.

2.2.8 Compliant resins for structural applications are to be of types accepted by PH.R.S. and are to be used strictly in accordance with the manufacturer’s recommendations. The plans submitted for approval are to identify which compliant resins are used in different applications. Surface preparations and over bonding are also to be identified on the submitted plans.

2.2.9 Proposals for the use of structural filleting applications using compliant resin are to be submitted in detail. Such proposals will be subject to individual consideration.

2.3 Gel coat

2.3.1 Gel coat is to be of a thickness of 0,3 - 0,5 mm. Gel coats based on orthophthalic polyester resin systems are not acceptable. Gel coat and topcoat shall be produced of polyester satisfying the requirements of PHRS-A resins. All gel coats are to be used strictly in accordance with the manufacturer's recommendations. The curing system is to be in accordance with 2.2.5. Those parts of the inner side of the laminates that can be exposed to water are to be given a topcoat, which both protects the laminates and provides complete curing of these.

2.3.2 Where pigments are to be added, reference is to be made to 2.4. Where pigments are to be added by the Builder, the gel coat is to be allowed to stand for sufficient time to permit entrapped air to be released. The method of mixing is to be carried out strictly in accordance with the resin and pigment manufacturer's instructions. Color pigments and fillers are to be such that separation will not occur during spraying or application by hand.

2.3.3 Where the temperature of the gel coat resin is below that of the workshop, the gel coat resin is to be conditioned to attain the workshop temperature prior to use.

2.3.4 When the inspection of the mould is an agreed hold point, required by the quality plan, the mould is to be inspected by the attending Surveyor prior to gel coating. The Surveyor may also require witnessing the initial application of the gel coat.

2.3.5 Where a gel coat is not used, details of the proposed water barrier are to be submitted for consideration. Where a painted finish is to be adopted in place of a gel coat, a suitable tie coat may be required, in accordance with the paint manufacturer's recommendations.

2.3.6 Where the hull is of sandwich construction and built on a male plug mould, the water barrier on the outer surface of the hull will be specially considered.

2.4 Pigments, Fillers, Additives

2.4.1 Additives are only to be added by the resin manufacturer, in accordance with the agreed procedure and tested accordingly.

2.4.2 Fillers added by a Builder are to be of the dispersed type. The amount of filler that may be added to a resin is to be recommended by the resin manufacturer and is not to alter significantly the viscosity of the resin nor is it to affect the overall strength properties of the laminate. The percentage of fillers is not to exceed, as a rule, 10% of the mass of the resin, with a maximum of 2% for the thixotropic agents and 5% for the flame retarders. Recommendations by the resin manufacturer to adopt amounts of fillers in excess of 13% by weight of the base resin will be subject to individual approval and testing. Fillers are to be carefully and thoroughly mixed into the base resin, that is then to be allowed to stand to ensure that the entrapped air is released. The resin manufacturer's recommendations regarding the method of mixing are to be followed. Fillers are not to be used in the structural laminates forming the boundaries of oil fuel and water tanks.

2.4.3 The amount of fire retardant additives may be in excess of that indicated in 2.4.2, provided that due account is taken of the reduced mechanical properties when determining scantlings in accordance with the Rules. Where laminates are required to have fire retardant or restricting properties, details of the proposals are to be submitted for approval. Test results of independently tested fire retardant and fire restricting materials are to be submitted for design purposes. All fire retardant resin systems are to be used strictly in accordance with the resin manufacturer’s recommendations. The attention of Owners and Builders is drawn to the additional statutory regulations regarding fire safety that may be imposed by the National Authority of the country in which the craft is to be registered or the Governments of the states to be visited. The use of fire retardant and fire restricting materials in craft required to comply with statutory requirements, will be subject to the individual approval of the National Authority of the country in which the craft is to be registered, or PH.R.S., where authorized to undertake this work on behalf of the National Authority.

2.4.4 Lightweight surfacing materials for reinforcing resin rich surfaces are to be compatible with the resin being used. Where peel ply materials are to be used, the finish is to be such that, after removal, it does not interfere with any subsequent bonding processes.

2.4.5 The types of color pigments used are to be such that the final cure of the resin is not affected. Pigments may be added to the resin by either the resin manufacturer or the moulder. When added by the moulder, it is to be as a paste dispersal in the same or compatible resin. Pre-pigmented gel coats are recommended. Where pigments are to be added by the Builder, thorough mixing is essential. The amount and type of pigment added is not to exceed that recommended by the resin manufacturer for a satisfactory depth of color. Proposals to use amounts of pigment solids in excess of five per cent, by weight, of the base resin, will be subject to individual approval and testing. It is recommended that pigments are not to be added to the gel coat or laminating resins used in the under-water portion of the hull laminate or in laminates forming the boundaries of oil fuel and water tanks. The addition of pigments is not to unduly affect the gelation time of the resin system or the physical properties of the gel coat layer of the laminate produced. The resin and/or pigment manufacturer’s written confirmation in this respect is to be obtained and recorded in the Builder’s quality control documentation.

2.4.6 Release agents are to have no inhibiting effect on the gel coat resin and are to be those recommended by the resin manufacturer.

2.5 Fiber Reinforcements

2.5.1 All fiber reinforcements are to be of a type approved by PH.R.S. Fiber reinforcements considered are E, S or R glass fibers, and carbon and aramid fibers. The use of hybrid reinforcing materials is also acceptable. A certificate showing chemical composition is to be presented, or a chemical analysis is to be carried out showing that the requirements to the various types have been met. To be considered a reinforced plastic, the properties of the cured laminate of resin and fiber must exceed those of the cured clear resin without fiber. Where coupling agents are used, they are to be of the silane type, and are to be compatible with the laminating resins. Fiber reinforcements can be used in the form of chopped strands (emulsion bound mat), fine-meshed or coarse-grained woven cloths (woven roving), which are chopped on application or used in their continuous form, or unidirectional cloths.

2.5.2 All reinforcements are to be stored strictly in accordance with the manufacturer’s recommendations. Rolls of reinforcement are to remain in their original packaging to minimize contamination. The quality control documentation is to provide traceability of all reinforcements using the manufacturer’s batch numbers. The materials are to be free of imperfections, discoloration, foreign matter and other defects.

2.5.3 Pre-impregnated reinforcements are to be suitably stored in an approved area. Detailed storage records are to be maintained as part of the quality control documentation.

2.5.4 In the submerged part of the hull the reinforcement layer next to the gelcoat should contain as little water-soluble bonding components as possible, and, normally, spray roving or powder bounded mat are to be used.

2.6 Core materials

2.6.1 Core materials for sandwich constructions are to be of a type approved by PH.R.S. or other recognized Classification Society. All core materials are to be used in accordance with the manufacturer’s application procedure, a copy of which is to be submitted for information, with the relevant construction plans of the craft. A second copy is to be incorporated into the quality control documentation. Core materials are to have sufficient compression and shearing strength. If the core serves only as a base for the laminates, e.g. in stiffeners, no requirements are made to the strength of the core material. Wooden cores are to be waterproof plywood or other materials, which do not swell. Solid wood is to be used as little as possible below the water line. Core materials shall have stable long time properties; continuous chemical processes, diffusion, etc. shall not affect the physical properties of the material. If considered, necessary documentation may be required. On delivery, the surface of the material shall be such that no further machining or grinding is required to obtain proper bonding of the material. Core materials shall normally be compatible with polyester, vinylester and epoxy resins. Core materials with limited compatibility may be accepted upon special consideration. Limitations will be specified in the certificate.

2.6.2 Where necessary, foam core materials are to be conditioned in accordance with the manufacturer’s recommendations. Conditioning at an elevated temperature, in excess of that which may be experienced in service, may be necessary to ensure the release of any entrapped residual gaseous blowing agents from the cells of the foam core.

2.7 Core Bonding & Adhesive Materials

2.7.1 Core bonding materials for structural applications are to be of types accepted by PH.R.S, and are to be used strictly in accordance with the manufacturer's instructions. Details of the proposed core bonding paste to be used with the core material are to be indicated on the Materials Data Sheet and the appropriate construction plans. The Builder is to demonstrate that a uniform thickness of bonding paste is obtained by use of notched trowels or comb gauges.

2.7.2 Adhesives for structural applications are to be of types accepted by PH.R.S. and are to be used strictly in accordance with the manufacturer's recommendations. Details concerning the handling, mixing and application of adhesives are to form part of the Builder's production plan. Particular attention is to be given to the surface preparation and cleanliness of the surfaces to be bonded. Where excessive unevenness of the faying surfaces exists, a suitable gap-filling adhesive is to be used, or local undulations removed by the application of additional reinforcements. The Builder's quality plan is to identify the level of training required for personnel involved in the application of structural adhesives.

2.8 Materials for Integrated Structures

2.8.1 Metallic materials, such as steel or aluminum alloys, used in the construction, are to comply with the requirements of 1.1.2. Where structural members or components manufactured from these or other materials are to be encapsulated within, or structurally bonded to, laminates, the material is not to adversely affect the cure of the resin system. The metals used are to be resistant to seawater corrosion, as well as to fuel corrosion. The surface area of the component that will be in contact with the resin is to be thoroughly cleaned, degreased and, where practicable, either shot blasted or abraded to provide a key.

2.8.2 Where metallic sections are to be bolted into a structure, the bolting requirements are to be determined by direct calculations that are to be submitted for consideration. Appropriate precautions against corrosion are to be taken.

2.8.3 Where plywood and timber members are to be used in structural applications and are to be laminated onto, or encapsulated within, the laminate, the surface of the wood is to be suitably prepared and primed prior to laminating.

SECTION 3 Approval of raw materials

3.1 General

3.1.1 The boat manufacturer is to keep documentation for raw materials, which should be available at request on inspection.

3.1.2 A type-approval for each material is granted for a period of five years. At the end of the approval period the manufacturer is to apply for renewal of the approval, which normally is assessed on the basis of random sample testing.

3.1.3 When applying for approval, the manufacturer is to submit data and information about the product and production. If the data and information submitted are considered to be satisfactory, an approval testing is to be carried out. All requirements specified for the materials in question are to be checked.

3.1.4 The manufacturer shall ensure that the production of a type approved material is carried out according to the manufacturing procedures adopted at the time of type approval and that all the produced materials bear a suitable identification mark relevant to PH.R.S. type approval. Subject to what is stated above, PH.R.S. reserves the right to require, at its discretion, checks during the production, or even to require either partial or full repetition of tests and checks required for type approval. The validity of the Type Approval Certificate expires in the case of unsatisfactory results of the above tests and checks, and the manufacturer is to be notified by the Head Office.

3.1.5 Other internationally recognized test methods than those given for the respective materials may be adopted upon prior agreement.

3.2 Resin Systems

3.2.1 Approval of polyester is divided into the following quality grades:

- Grade **PH.R.S.-A**: Quality with good water resistance.
- Grade **PH.R.S.-B**: Quality with normal water resistance.
- Grade **PH.R.S.-C**: Quality with normal water resistance.

3.2.2 Resin is to be approved by the Society or other recognized Classification Society or National Authority. Requirements for resins in liquid and cured condition are given in Table 3.2.1 and Table 3.2.2 respectively.

3.2.3 Data sheets are to provide liquid and cured form physical and mechanical properties, as well as curing characteristics at a specified temperature indicating the gel time variation with air temperature and amount of catalyst and accelerator, or amount of hardener. Cured mechanical properties are to be given for un-reinforced resin. Batch data sheets are to be supplied with each delivery, indicating the physical and mechanical properties of the particular delivered batch. All resins are to be used within 90 days of their specified ”batch date”, unless acceptable by the materials manufacturer. Batch data sheets are to be retained by the builder for a period of three years.

3.2.4 Properties of a resin are to be for the form of the resin actually used in production, with all additives and fillers included. The amount of silicon dioxide or other materials added to provide thixotropy is to be the minimum necessary to resist flowing or draining. Liquid and cured condition properties of resins as given in Table 3.2.1 and Table 3.2.2 are to be provided, for the gel coat resin and laminating resin, and, if different, for the skin coat:

Table 3.2.1: Requirements for resin in liquid condition

Property	Test method according to:	Required values for approval
Density	ISO 1675, ISO 2811	Manufacturer's nominal value ± 5%
Viscosity	- Brookfield: ISO 2555 - Cone/Plate: ISO 2884	Manufacturer's nominal value ± 20%
Acid value	ISO 2114, DIN 53402	Manufacturer's nominal value ± 10%
Monomer content	ISO 4901	Manufacturer's nominal value ± 10%
Mineral content	DIN 16945	Max. value 5%
Gel time	ISO 2535	Manufacturer's nominal value ± 20%
Linear curing shrinkage	ASTM D 2566	Manufacturer's nominal value

Table 3.2.2: Requirements for resin in cured condition

Property	Test method according to:	Required values for approval testing		
		Grade PH.R.S.-A	Grade PH.R.S.-B	Grade PH.R.S.-C
Density		Manufacturer's nominal value	Manufacturer's nominal value	Manufacturer's nominal value
Tensile Strength	ISO 527	Min 55 MPa	Min 45 MPa	Min 40 Mpa
Tensile Modulus	ISO 527	Min 3000 MPa	Min 3000 MPa	Min 3000 Mpa
Tensile Elongation at Break	ISO 527	Min 2,5 %	Min 1,5 %	Min 1,2 %
Flexural Strength	ISO 178	Min 100 Mpa	Min 80 MPa	Min 80 Mpa
Flexural Modulus	ISO 178	Min 2700 MPa	Min 2700 MPa	Min 2700 Mpa
Volume Shrinkage	ISO 3521	Manufacturer's Nominal value +5%	Manufacturer's Nominal value +5%	Manufacturer's Nominal value +5%
Hardness	EN 59	Min. 35	Min. 35	Min. 35
Heat Deflection Temp.	ISO 75 Method A	Min. 75°C	Min. 62°C	Min. 53°C
Water absorption	ISO 62	Max. 80 mg	Max. 100 mg	Max. 100 m

3.3 Gel coat

3.3.1 Gelcoat and topcoat shall be produced of polyester satisfying the requirements of Grade PH.R.S.-A. The resin must not contain more than 10% pigments and other filling compounds. The gel coat is to have higher ductility than the resin employed. This requirement is deemed complied with when the difference between the elongation after fracture of the gel coat and of the resin (without glass reinforcement) is at least 1%.

3.4 Fiber Reinforcements

3.4.1 For reinforcing materials, the specification is to indicate the fiber type and form, weave, fiber orientation, weight, physical data, and mechanical properties. Detailed storage records are to be maintained as part of the quality control documentation.

3.4.2 The reinforcement is to be free from foreign matter. For E-glass type fibers, the sum of Na_2O and K_2O is to be less than 1%. A certificate showing chemical composition is to be presented, or a chemical analysis is to be carried out showing that the requirements of E-glass have been met (SiO_2 52-56%, CaO 16-25%, Al_2O_3 12-16%, $B2O_3$ 6-12%, Na_2O+K_2O 0-1% and MgO 0-6%). Fibers made of other glass qualities may be used, provided that their mechanical properties and hydrolytic resistance are equally good or better.

3.4.3 Glass fibers are to be produced as continuous fibers. They are tested in that product form in which are to be used. For roving which will be applied by spraying, a demonstration is to be made in the surveyor’s presence, to show that the roving is suited to this form of application.

3.4.4 Requirements for glass fiber products are given in Table 3.4.1.

Table 3.4.1: Requirements for glass fiber products

Property	Test method according to:	Required values for approval
Moisture content	ISO 3344:1977	Max 0.2% on delivery (0.5% for CSM)
Loss on ignition	ISO 1887:1980	Manufacturer’s nominal value +20%
Weight per unit length or area	Woven Roving: ISO 1889:1987 Chopped Mat: ISO 3374:1990 Woven Roving: ISO 4605:1978	Manufacturer’s nominal value –5% to +10%

3.5 Core material

3.5.1 Core material specifications are to indicate the material specification number, material type, density, and recommendation for storage, handling and use. Materials dealt with by the requirements of the following paragraphs are the rigid expanded foam plastics and balsa wood; the use of materials other than the above, shall be considered by the Head Office on the basis of equivalence criteria.

3.5.2 Rigid expanded foam plastics
Rigid expanded foam plastics are intended to mean Expanded Polyurethane (PU) and Polyvinylchloride (PVC). Rigid expanded foam plastics are to:

- be of closed-cell types and impervious to water, fuel and oils,
- have good aging stability,
- be compatible with the resin system,
- have good strength retention at 60°C,
- have characteristics and mechanical properties of not less than those indicated in Table 3.5.1, and
- if manufactured into formable sheets of small blocks, the open weave backing material and adhesive are to be compatible and soluble, respectively, with the laminating resin.

3.5.3 Balsa wood
For type approval of balsa wood, it is to:

- be end grained,
- have been chemically treated against fungal and insect attack and kiln dried shortly after felling,
- have been sterilized,
- have been homogenized,
- have average moisture content of 12%,
- have characteristics and mechanical properties of not less than those indicated in Table 3.5.2 and
- if manufactured into formable sheets of small blocks, the open weave backing material and adhesive are to be compatible and soluble, respectively, with the laminating resin.

It is assumed that manufacturing process is such that balsa wood fibres are right-angled with respect to the fibres of surface laminates of sandwich.

3.5.4 Synthetic ‘felt’ type core materials are to be specially approved. Other types of core materials will be individually considered, on the basis of these Rules, in relation to their characteristics and intended application. For core materials of particular composition or structure, additional requirements may be introduced. Expanded polystyrenes may be used only as filling or buoyancy materials. Polyester fiber or vinylester mat is not considered a lightweight structural core, and use will be subject to special consideration. Shear strength for use in the design is to be verified by test. Construction methods and procedures for core materials are to be in strict accordance with core manufacturer' recommendations.

Table 3.5.1: Minimum characteristics and mechanical properties of rigid expanded foams at 20 °C.

Material	**Apparent Density (kg/m^3)**	**Strength (N/mm^2)**			**Modulus of Elasticity (N/mm^2)**	
		Tensile`	**Compressive**	**Shear**	**Compressive**	**Shear**
Polyurethane	96	0,85	0,60	0,50	17,20	8,50
PVC	60					

Table 3.5.2: Minimum characteristics and mechanical properties of end-grain balsa

Apparent density (kg/m^3)	**Strength (N/mm^2)**					**Compressive modulus of elasticity (N/mm^2)**		**Shear modulus of elasticity (N/mm^2)**
	Compressive		**Tensile**		**Shear**			
	Direction of stress					**Direction of stress**		
	Parallel to grain	**Perpend. to grain**	**Parallel to grain**	**Perpend. to grain**		**Parallel to grain**	**Perpend. to grain**	
96	5,00	0,35	9,00	0,44	1,10	2300	35,20	105
144	10,60	0,57	14,60	0,70	1,64	3900	67,80	129
176	12,80	0,68	20,50	0,80	2,00	5300	89,60	145

3.6 Materials for Integrated Structures

3.6.1 Plywood

Plywood, for structural applications, is to be of a high quality, marine grade material approved by PH.R.S. In general, the plywood is to be manufactured to a high standard of finish in accordance with ISO or other recognized standards, and is to meet, or be equivalent to, the following general requirements:

- Have good quality face and core veneers of a durable hardwood species.
- The number of veneers is to be in accordance with **Table 3.6.1**.
- The veneers are to be bonded with a WBP (water and boil proof) type adhesive
- Have a moisture content not exceeding 15%.

Butts and seams are to be scarfed or butt strapped where necessary. The length of the scarf is to be no less than eight times the plywood thickness. The scarf is to be glued and, if made in situ, fitted with a backing strap of width not less than 10 times the panel thickness.

3.6.2 Timber

The acceptance of timber in the construction will be subjected to individual consideration depending upon the intended use and timber involved. Solid timber as core material in stiffeners is to be avoided as far as possible. Timber is to be of good quality and properly seasoned, free from heart, sapwood, decay, insect attack, splits, shakes and other imperfections that would adversely affect the efficiency of the material. It is also to be generally free from knots, although an occasional sound intergrown knot would be acceptable. The moisture content of timber for bonded or over-laminated applications using polyester or epoxy resins is, in general, to be nominally 15%. Contents slightly greater than this value are recommended when resorcinol glues are used, and contents slightly lower than this value are required when phenolic or urea-formaldehyde resins are used.

Table 3.6.1: Number of veneers in Plywood

Board thickness (mm)	Minimum Number of plies
Up to 9	3
10-19	5
20 and above	7

SECTION 4 Manufacturing

4.1 Manufacturing and Storage Premises & Equipment

4.1.1 Manufacturing premises are to be closed spaces properly equipped and arranged so that the raw material manufacturer's recommendations and builder's standards for handling, laminating and curing can be followed.

4.1.2 Workshops and equipment are to be in accordance with good manufacturing practice and be to the satisfaction of the Surveyor. The Surveyor is to be allowed unrestricted access during working hours to such parts of the Builder's establishment as may be necessary to ensure that the requirements of the Rules are being complied with.

4.1.3 Premises are to be fully enclosed, dry, clean, shaded from the sun, and adequately ventilated to remove fumes, overspray, and dust from the moulds and laminating area and properly and adequately lighted. Precautions are to be taken to avoid any effects on the resin cure due to direct sunlight or artificial lighting. Laminating areas are to be remote from operations creating dust, so that raw materials and moulds are not contaminated. Draught through doors, windows etc. and direct sunlight is not acceptable in places where lamination and curing are in progress.

4.1.4 The air temperature in the moulding shops is to be +15°C ÷ +28°C. The stipulated minimum temperature is to be attained at least 24 hours before commencement of lamination, and is to be maintainable regardless of the outdoor air temperature. The temperature in the moulding shops is not to vary by more than ± 3°C during 24 hours. The ventilation plant is to be so arranged that the curing process is not affected. Where the temperature exceeds 25°C, special consideration is to be given to the resin system.

4.1.5 The relative humidity of the air is to be kept constant, so that condensation is avoided, and is not to exceed 70%. In areas where spray moulding is taking place, the air humidity is not to be less than 40%. The stipulated air humidity is to be maintainable regardless of outdoor air temperature and humidity.

4.1.6 Deviations from the values given in 4.1.4 and 4.1.5 will be considered, provided temperatures and humidity are within the limits recommended by the manufacturer of the raw material and are reviewed by the Society prior to laminating.

4.1.7 Sufficient temperature and humidity monitoring equipment is to be provided and detailed records are to be kept in accordance with the Quality Assurance system. In larger shops, there is to be at least one thermohydrograph for each 1500 m^2 where lamination is carried out. The location of the instruments in the premises is to be as neutral as possible.

4.1.8 Scaffolding is to be provided, where necessary, to avoid standing on cores or on laminated surfaces. Such arrangements are to conform to the National Authority requirements and are not, in general, to be connected to the molding or impinge on the mold surface.

4.1.9 It is the responsibility of the Builder to ensure that the ventilation and working conditions, together with discharges into the atmosphere, are such that levels of substances are within the limits specified in any pertinent National or International legislation.

4.1.10 Spaces where the boats are assembled may be allowed to be open.

4.1.11 Storage premises are to be closed spaces, properly equipped and arranged so that the material supplier's directions for storage and handling of the raw materials can be followed. The temperature and the relative humidity of the storage premises shall be controllable. Storage premises for reinforcing materials are to be kept clean and as free from dust as possible, so that the raw material is not contaminated or degraded. Materials are to remain sealed in storage, as recommended by the manufacturer.

4.1.12 Polyester, gelcoat and the like should not be stored in temperatures that will affect the qualities of the material. The storage period is not to exceed the shelf lives. Fillers and additives are to be stored in closed containers impervious to humidity and dust. Core materials are to be stored in a dry space and protected against damage. They are to be contained in their protective packaging until immediately prior to use. Where resin tanks or drums are stored outdoors, it is the Builder's responsibility to ensure that the resin manufacturer's storage conditions are complied with.

4.1.13 Before use, fiber reinforcements are to be stored for at least 48 hours at a temperature and humidity similar to that of the laminating premises.

4.1.14 Materials that may be considered hazardous to each other are to be stored separately. Catalyst is to be stored in a cool, dry location away from the manufacturing facility, in accordance with fire and insurance codes.

4.1.15 When the manufacturing and storage premises are found to be in compliance with the requirements of 4.1, a relevant certificate of fitness of the manufacturing and storage premises may be issued, upon the Builder's request.

4.2 Construction Methods

4.2.1 Fabrication
The use of fabricating procedures differing from those given below will be specially considered. Normally, the laminate is to be laid-up by one of the following methods:

- Hand lay-up or contact process
- Vacuum Bagging
- Resin Impregnation
- Resin Transfer Molding (RTM)
- Resin Infusion
- Pre-preg

The building process description is to be submitted for review by the builder before construction starts. Information on the following items is to be included.

Description of construction facilities, including environmental control, material storage and handling.

Specifications for resins, reinforcing products, and core materials, including the manufacturers recommendations.

Lay-up procedures, including type, orientation of reinforcements, sequence, resin mixing methods, and resin pot-life limits.

Secondary bonding procedures

Inspection and quality control systems

Laminate properties derived from destructive qualification testing, including sample check sheets, forms, and guides.

4.2.2 Workmanship

Gelcoat is, as far as practicable, to be applied by spraying. Downwards spread of the gelcoat after application is not acceptable. Normally, the gelcoat is not to be allowed to cure for more than 24 hours before commencement of laminating. Gelcoat is not required if the laminate is coated with an equivalent surface treatment. Where the inner side of laminates may be exposed to water, a suitable coating for protection (e.g. topcoat) is to be applied. Stiffening members and accommodation components moulded into these laminates are also to have a sufficient layer of coating. Laminate edges exposed to water are to be sealed by 0,3 mm topcoat or equivalent. Where the edge of a sandwich panel can be exposed to water, it is to be covered by laminate.

Moulding of important hull members is to be carried out only by skilled workers under the supervision of a foreman experienced in the judging of the workmanship of the quality of the finished laminate. The foreman is also to ensure that the production is in accordance with the Rules.

Large structural parts are to be properly supported after removal from the mould.

Moulding-in of stiffeners, accommodation components etc. is as far as possible to be carried out in wet laminate. Laminate which has cured for more than 24 hours has to be cleaned to remove possible deposit of wax and ground so that the fibers are exposed prior to any further lamination of structural parts.

After completion of lamination, the laminates are to cure for at least 48 hours at an air temperature of +18°C minimum. Curing at a higher temperature and a shorter curing time may be accepted on the basis of control of the curing rate.

A layer or ply of reinforcing material may consist of a number of pieces. The pieces are to be lapped along their edges and ends. The width of each lap is to be not less than 50 mm. Unless otherwise specifically approved, no laps in the various plies of a laminate are to be closer than 100 mm to each other. Transitions in laminate thickness are to be tapered over a length not less than three times the thickness of the thicker laminate. A gradual transition in fiber reinforcement is to be provided between bi-directional and unidirectional laminates.

Sandwich panels may be laminated with cores that are effective in resisting bending, tension, compression, shear and deflection (e.g. plywood) or are essentially ineffective in resisting bending, tension, compression and deflection, but capable of carrying shear loads, (i.e. balsa wood and plastic foam). All cores are to be effectively bonded to the skins in accordance with the manufacturer's recommendation (e.g. vacuum bag techniques using an approved bedding putty). Joints in core materials are to be scarphed and bonded, or connected by similar effective means. Where sandwich panels with ineffective cores are used in way of mechanically connected structures, gears and equipment, a core effective in resisting bearing, shear, flexure and compression is to be inserted. The inserts are to be bonded to the skins or faces of the sandwich and to the adjacent core. The ply of skin laminate in contact with each face of a core material is to be chopped-strand mat. The mat is to be thoroughly impregnated with resin and the core is to be coated with resin before lay-up. For foam cores, the resin is to be sufficiently rolled to ensure that all voids are filled, and the coat of resin for wood cores should be enough to seal the grain of the wood.

Secondary bonds should only be used when a primary bond cannot be achieved. Wherever possible, peel-ply should be applied to the outer layer of the surface requiring the secondary bond. When preparing for a secondary bond, the following criteria, along with the manufacturer recommendations, should be adhered to:

The area is to be clean and free from all foreign particles, such as wax, grease, dirt, and dust.

When grinding is required, the grinding is not to damage any of the structural glass fibers, thus weakening the laminate, especially in highly stressed areas.

In general, the first ply of the secondary lay-up is to be chopped-strand mat. The final ply of laminate along the bond line of the cured laminate is to be preferably chopped-strand mat.

4.2.3 Moulds

Moulds are to be constructed of a suitable material and are to be adequately stiffened to maintain their overall shape and fairness of form. The materials used in the construction of moulds are not to affect the resin cure. During laminating, provisions shall be taken to ensure satisfactory access, to permit proper carrying out of laminating.

The finish of a mould is to be such that the mouldings produced are suitable for the purpose intended. The resultant aesthetic appearance of the moulding is strictly a matter between moulder and Owner.

Where multiple section moulds are used, the sections are to be carefully aligned to the attending Surveyor's satisfaction prior to moulding. Mismatch between mould sections is to be avoided.

The release agent (e.g. mould wax, etc.) is to be of a type recommended by the resin manufacturer and is not to affect the cure of the resin.

Prior to use, all moulds are to be cleaned, dried and conditioned to the workshop temperature.

Mouldings are to be adequately supported to avoid distortion during final cure. Lifting arrangements are to be designed so that mouldings are subjected to minimal distortion and unnecessary stressing. Scaffoldings are to be erected to enable an easy access to the work and for inspection. As a rule, these scaffoldings are not to be in contact with the laminate.

Where metallic moulds are used, welding is to be minimized to avoid distortion of panels.

4.2.4 Materials Handling

All arrangements are to be taken by the shipyard to ensure the storage of raw materials in conditions in accordance with those required by the materials suppliers. The attention is drawn on the necessity to foresee the working up of material components sufficiently in advance, in order to use them at the workshop temperature.

The arrangements for the receipt, verification against certificates of conformity, and subsequent handling of materials are to be covered by the Builder’s quality control procedures, such that the materials do not suffer contamination or degradation and bear adequate identification at all times. Storage is to be so arranged, that materials are used by batch, wherever possible, in order of receipt. Materials are not to be used after the manufacturer’s date of expiry, except with the prior agreement of PH.R.S. and new certificates of conformity being obtained from the material manufacturer. Details of the new certificates of conformity are to be entered into the quality control system.

4.3 Construction Process

4.3.1 General

Provision is made in this Section for the construction of craft built of fiber reinforced plastic using thermosetting materials. Craft built of fiber reinforced thermoplastic materials will be subject to individual consideration.

This Section contains the general Rule requirements to be complied with in the construction of fiber-reinforced craft being built under survey. Where detailed requirements are not defined, good boat building practices are to be applied.

4.3.2 Resin preparation

Before decanting, all resins are to be thoroughly mixed, deaerated and conditioned to the shop temperature in accordance with the resin manufacturer's instructions.

A peroxide catalyst must never be directly mixed to the cobalt accelerator, because of their explosive reaction. In all cases, the catalyst - or accelerator - is to be carefully distributed in resin before adding the other constituent. Mixing is to be carefully carried out, and slow enough to avoid the trapping of air into the resin.

All measuring / pumping equipment is to be certified and suitable for the quantity of material being measured. Valid certificates of calibration are to form part of the quality control documentation.

Quality control records are to be maintained to provide traceability and identification of the resin and all additives used in the resin system. Batch numbers are to be identified.

Any additive used as a production aid, must be the one recommended by the resin manufacturer and is not to alter the mechanical properties or the characteristics of the cured laminate.

4.3.3 Laminating

Production is to follow all necessary approved construction plans, in accordance with the PH.R.S. accepted quality plan.

Laminating is to be carried out by skilled operators, who are to be trained and qualified to the level required by the Builder's quality plan.

The gel coat resin is to be applied by brush, roller or spraying equipment to give a uniform, nominal film of maximum thickness of 0,5 mm. For construction moulded on a male mould, the outer surface of the hull is to be covered with a thick layer of resin or a resin-based product before painting. The resin used is to offer the properties of a surface coating.

The period of exposure of the gel coat between gelation and the application of the first layer of reinforcement is, in general, to be as short as practicable. In no case is this to be longer than that recommended by the resin manufacturer for that particular resin system. Written confirmation of this is to be obtained and recorded in the Builder's quality control documentation.

All mouldings are to be manufactured from layers of reinforcement, laid in the approved sequence and orientation, each layer being thoroughly impregnated and consolidated to give the required fiber content, by weight, in accordance with the approved plans. All arrangements are to be made to ensure a sufficient elimination of air bubbles with a suitable set of tools. The elimination of bubbles is to be regularly carried out during lamination

In laminates containing multiple layers of woven reinforcement, woven reinforcement may be laid on woven reinforcement, provided that the inter-laminar shear strength is not less than 13,8 N/mm^2; otherwise, a layer of random fiber reinforcement is to be laid alternately with the woven reinforcements.

Excessive exothermic heat generation, caused by thick laminate construction, is to be avoided. Where thick laminates are to be laid, the Builder is to demonstrate to the Surveyor's satisfaction, that the number of plies can be laid wet on wet and that the resultant temperature during the cure cycle does not have any deleterious effect on the mechanical properties of the cured laminate.

Laminating is to be carried out in a sequence, such that the time lapse between the application of the successive layers is within the limits recommended by the resin manufacturer, and documented in the quality control procedures for the particular resin system. Similarly, the time lapse between the forming and bonding of structural members is to be kept within these limits and, where this is not practicable, the surface of the laminate is to be prepared, in accordance with the resin manufacturer's instructions, to improve the bond.

When laminating is interrupted, and where a system other than epoxy resin is being used, the first of any subsequent layers of reinforcement to be laid in that area, is to be of the chopped fiber type, to enhance the interlaminar shear strength properties of the laminate.

In case of local default noted during the lamination, a repair may be carried out before the laying up of the following layer. The timing and the extent of the repair have to be noted by the shipyard.

4.3.4 Fiber content

To ensure that the resultant thickness of the structure is not less than that indicated on the approved plans, the nominal fiber content, by weight, of the individual plies and overall laminate is to be controlled on the basis of the weight of the constituent materials.

A method of validating the completed laminate thickness is to be agreed between the Builder and Surveyor. Where electronic thickness measurement methods are employed, the equipment is to be calibrated against a laminate of identical construction. Alternatively, a series of areas are to be identified within the craft, where samples can be taken to validate the thickness of the laminate (e.g. in way of overboard discharges/ seawater intakes/deck openings etc.).

4.3.5 Laminate schedule

The laminate schedule is to clearly define the sequence of production, identify the specific materials to be used, and state relevant details regarding overlapping, staggering thickness and tailoring of reinforcements.

Areas of local deficiency requiring additional reinforcement and areas that have been found to be of increased thickness are to be recorded in the quality control documentation.

4.3.6 Spray laminating

The equipment for spray deposition of resin and glass fibers is to be inspected during the Workshop Inspection and a sample panel produced. Documentary evidence of maintenance, calibration, catalyst content, fiber length and overall fiber content by weight are to be entered into the quality control documentation. The spray pattern is to give an even distribution, as recommended by the manufacturer of the equipment, and is to be to the satisfaction of the attending Surveyor.

Unless the mechanical properties are confirmed by testing, the chopped fiber length for a structural laminate is to be not less than 35 mm. In no case is the fiber length to be less than 25 mm.

Spray equipment is only to be operated by trained and competent personnel. Training certification is to form part of the quality control documentation. The use of spray lay-up is to be limited to the parts of the structure to which sufficient access can be obtained, to ensure satisfactory laminating.

Consolidation is to be carried out as soon as it is practicable after spray deposition. In general, this is to be carried out when a weight of reinforcement, equivalent to a thickness of 2-3 mm, has been deposited. Next to the gelcoat, rolling out is to be done for maximum 1,5 mm thickness of finished laminate. The thickness of the resulting laminate is to be periodically checked and recorded.

Particular attention is to be given to localized thinning of the laminate in way of chines, coamings, knuckles and openings. Further deposition may be required in such areas, to compensate for any reduction in thickness. Alternatively, layers of other equivalent reinforcements may be laid to achieve the required local thickness.

4.3.7 Release and curing

After completion of the lay-up, the moulding is to be left in the mould for a period to allow the resin to cure before being removed. This period can vary with ambient temperature, the type of resin and the complexity of the moulding, but is to be not less than 12 hours or that recommended by the resin manufacturer.

Care is to be exercised during removal from the mould to ensure that the hull, deck and other large assemblies are adequately braced and supported, to avoid being damaged and maintain the form of the moulding.

Upon release from the mould, the surface coating is to be examined and is not to show defaults such as bubbles, blisters, pinholes and wrinkles.

Where female moulds are adopted, all primary stiffening and transverse bulkheads are to be installed prior to removal from the mould, unless otherwise agreed on the approved construction schedule and plans.

Mouldings are not to be stored outside of the workshop environment until they have attained the stage of cure recommended by the resin manufacturer for that particular resin. Provision is to be made for mouldings to be protected against adverse weather conditions.

Mouldings are, in general, to be stabilized in the moulding environment for at least 24 hours, or that recommended by the resin manufacturer, before the application of any special cure treatment, details of which are to be submitted for approval. Care is to be taken to avoid any sudden difference in temperature and the increase in temperature during the heating process is to be progressive, due to this fact, the recommendations of the manufacturers of resin are to be respected.

Removal from the mould is not to be attempted, until a minimum Barcol reading recommended by the resin manufacturer or a value of 20 has been attained. Subsequently, the moulding is not to be moved outside of the controlled environment until the minimum Barcol reading recommended by the resin manufacturer or 35, whichever is less, has been recorded.

4.3.8 Sandwich construction

The methods used in sandwich construction are, in general, to be either wet or dry core bonding techniques or by laminating directly onto the core (e.g. plug moulding).

Where the core material is to be laid onto a pre-moulded skin, it is to be laid as soon as practicable after the laminate cure has passed the exothermic stage.

Where the core is applied to a laminated surface, particular care is to be taken to ensure that a uniform bond is obtained. Where a core is to be applied to an uneven surface, the Surveyor may request additional building up of the surface or contouring of the core to suit. The manufacturing process and workmanship should be such that gaps or joints in the core are filled up with polyester, cement or filler materials.

Where resins other than epoxy are being used, the reinforcement against either side of the core is to be of the chopped strand mat type.

Prior to bonding, the core is to be cleaned and primed (sealed), in accordance with the manufacturer’s recommendations. The primer is to be allowed to cure, and is not to inhibit the subsequent cure of the materials contained within the manufacturer's recommended bonding process. The primer is to seal the panels, including all the surfaces between the blocks of contoured material, without completely filling the surface cells.

Where panels of rigid core material are to be used, then dry vacuum bagging techniques are, in general, to be adopted. The core is to be prepared by providing 'breather' holes to ensure efficient removal of air under the core. Bonding paste is to be visible at such breather holes after vacuum bagging. The number and pitch of such 'breather' holes is to be in accordance with the core manufacturer's application procedure and any specific requirements of the core bonding paste manufacturer.

Thermoforming of core materials is to be carried out in accordance with the manufacturer's recommendations. Maximum temperature limits are to be strictly observed.

Where panels of contourable core material are to be used, it is necessary to ensure that the core is cut/scored through the entire thickness, such that the panels will conform to the desired shape of the moulding. The Builder is to demonstrate that the quantity of bonding material indicated in the core manufacturer's application procedure is sufficient to penetrate the full depth of the core between the blocks. It is recommended that grid scored panels using a carrier scrim cloth are adopted.

Where the edges of a panel are to be beveled to single skin, the rate of tapering is to be not greater than 30°. In areas where an insert (e.g. higher density foam or plywood) is to be used, the rate of taper is not to be greater than 45°.

In all application procedures cured, excess bonding material is to be removed and the panel cleaned and primed prior to the lamination of the final sandwich skin.

Backing or insert pads, where fitted in way of the attachment of fittings, are to be arranged so that the load can be satisfactorily transmitted into the surrounding structure. The contact area of these pads is to be suitably prepared and free from contamination.

Inserts in sandwich laminates are to be of a material capable of resisting crushing. Inserts are to be well bonded to the core material and to the laminate skins, in strict accordance with the approved plans.

Where plywood inserts are to be used, all edges are to be beveled at an angle of 45°. A small gap is to be provided around each insert to ensure the passage of bonding paste during the vacuum bagging process.

The level of vacuum applied for initial consolidation and during the cure period is not to be higher than that recommended by the relevant manufacturer of the materials being used, to avoid the possibility of evaporative boiling and excessive loss of monomer.

Shear ties between the inner and outer skins are to be provided at intervals and are to be detailed on the plans submitted for approval. Alternative shear tie arrangements will be individually considered.

4.3.9 Defects in the laminates

The manufacturing process of laminates shall be such as to avoid defects, of which the main ones are the following: surface cracks, surface or internal blistering due to the presence of air bubbles, cracks in the surface coating, internal areas with non-impregnated fibers, surface corrugation, surface areas not covered by resin or glass fiber reinforcement directly exposed to the external environment. Possible defects may be rectified by means of appropriate repair methods, to the satisfaction of the PH.R.S. Surveyor.

4.4 Quality System

4.4.1 Inspection

Inspection is to be carried out by the builders and Surveyors, as indicated and approved in the building process description and building quality control manual. A constant visual inspection of the laminating process is to be maintained by the builder. If improper curing or blistering of the laminate is observed, immediate remedial action is to be taken. Inspections of the following are to be carried out:

- Check the mould to ensure it is clean and releasing agent is properly applied.
- For gel coat, check thickness, uniformity, application and cure, before applying the first layer of reinforcement.
- Check resin formulation and mixing, check and record amounts of base resin, catalysts, hardeners, accelerators, additives and fillers.
- Check that reinforcements are uniformly impregnated and well wet-out, and that lay-up is in accordance with approved drawings, and standards of overlaps are complied with. All variation in materials should be brought to the attention of PH.R.S.
- Check and record resin/fiber ratios.
- Check that curing is occurring as specified. Immediate remedial action is to be taken when improper curing or blistering is noted.
- Visual overall inspection of completed lay-up for defects that can be corrected before release from the mould.
- Check and record hardness of cured hull prior to the release from mould.
- The ambient temperature, humidity, and gel time is to be monitored and recorded.

4.4.2 Faults

All faults are to be classified according to their severity and recorded, together with the remedial action taken, under the requirements of the Quality Assurance systems. Production faults are to be brought to the attention of the attending Surveyor and a rectification system is to be agreed upon.

4.4.3 Acceptance criteria

Classification is dependent upon the work being carried out in accordance with the approved plans and the requirements of an accepted quality system. The workmanship is to be to the satisfaction of the attending Surveyor. This will include the verification of the quality control documentation and the remedial action associated with all defects and deficiencies recorded. Proposed deviations from the approved plans are subject to PH.R.S. approval. An amended plan is to be submitted to the plan appraisal office, prior to any such changes being introduced.

4.4.4 Internal production control

The manufacturer is to have an efficient system for quality control, to ensure that all units in the proceeding production satisfy the specified requirements.
For each stage in the process, written instructions, i.e. building, specification, working drawings or equivalent should be available, which enables each individual operator to carry out the instructions in accordance with the approved standard specifications.

The results of controls should be reported and signed in a journal. Each unit shall be marked with a production number, which should be used for identification in the control journal.

The person responsible for the quality control should have necessary qualifications to value workmanship and quality of constructions in FRP.

The system for quality control should include routines for the following controls:

- Raw materials
- Storage and production conditions
- Workmanship for lamination and core build-up
- Compliance with the building specification
- After de-moulding, each moulded part should be weighed and the thickness measured to the extent specified in the approval.

CHAPTER 4 WOOD

SECTION 1 General

1.1 Timber species

1.1.1 The species of timber which are used for the various constructional members are to have the following properties:

1.2 Timber Quality

1.2.1 The timber is to be of good quality and properly seasoned and is to be free from sapwood and any noxious organisms (moulds, insects attack, larvae, splits, shakes, bacteria, etc.) which might impair its durability and structural efficiency. The timber for the centerline members is to be reasonably seasoned and where there is a risk of excessive drying-out, it is to be coated with boiled linseed oil or varnish, as soon as erected, to prevent splitting.

1.2.2 The moisture content at the time of use is to be not greater than 20%.

1.2.3 Knots may be tolerates when they are intergrown, provided that their diameter is less than $^1/_5$ of the dimension parallel to such diameter, measured on the section of the knot. The grain is to be straight.

1.2.4 For marine plywood, the elevated temperatures reached during drying and pressing rule out the possibility of survival of insects and larvae in the finished panels. Moreover this factor contributes in enabling the marine plywood to have a lower moisture content than that of solid timber of the same species in the same ambient conditions, tendering it less prone to attacks of mould. In any case the thickness; of the individual layers constituting the plywood or the lamella structure is to be reduced in direct proportion to the durability of the species used. The minimum number of plywood layers used in the construction is 3 for thickness not greater than 6mm and 5 for greater thickness.

1.2.5 Plywood sheets are to be stored flat on a level bed and under dry, well ventilated conditions. The moisture content is not to exceed 15%.

1.3 Certification and Checks of Timber Quality

1.3.1 The quality of timber, plywood and lamella structures is to be certified as complying with the provisions of 1.2 by the Builder to the PHRS Surveyor who, in the event of doubts or objections, will verify the circumstances by performing appropriate checks. Such certification is to refer to the checks carried out during building survey in the yard relative to the following characteristics:

a. for solid timber, mass density and moisture content,

b. for plywood and lamella structures, glueing test.

1.4 Manufacturing

1.4.1 The craft is to be suitably protected during the building period from adverse weather and climatic conditions. The minimum protection to be provided is normally a substantial and efficient roof projecting beyond the length and breadth of the craft.

1.4.2 All edges and cut-out areas are to be throughly sealed by glues, varnishes, paints or other suitable compositions to prevent moisture penetrating along the end- grain.

1.4.3 The layers forming the lamination are generally to be of the same timber species and are to be of an even moisture content. The grain of the layers is to me approximately parallel to the length of the member, and special attention is to be paid in the selection and assembly of the timber.

1.4.4 Where practicable the layers are to be continues and of this is not possible the layers are to be scarph jointed, the slope if the scarph being not greater than 1 in 10.

1.4.5 Attention is to be paid to the fastenings throughout particularly the size and disposition. The boring of the timber to receive the fastenings is to be properly executed according to the density of the timber and the type and material of the fastening.

1.5 Mechanical Properties

1.5.1 The species of timber suitable for construction are listed in Table 1.5.1 and Table 1.5.2 together with the following details:

a. commercial and scientific denomination,
b. natural durability and ease of impregnation,
c. average physical-mechanical characteristics at 12% moisture content
d. the durability classes are relative to the solid timber’s resistance to moulds

The use of timber species other than those stated in Table 1.5.1 may be accepted provided that the characteristics of the species proposed correspond with those of one of the species listed.

Table 1.5.1: Basic Physical-Mechanical Characteristics of Timbers for Construction

Commercial name	Origin (1)	Natural durability (2)	Mass density (kg/m³)	Ease of impregnation (2)	Mechanical characteristics (3)			
					R_f (N/mm²)	E_f (N/mm²)	R_c (N/mm²)	R_t (N/mm²)
Larice	Europe	C/D	550	3/4	89	12800	52	9.4
Castagno	Europe	B	600	4	59	8500	37	7.4
Olmo	Europe	D	650	2/3	89	10200	43	11.0
Quercia	Europe	B	710	4	125	15600	68	13.0
Teck	Asia	A	680	4	100	10600	58	13.0
Douglas Fir	America	C/D	500	3/4	85	13400	50	7.8
Cedar	America	B/C	380	3	51	7600	31	6.8
White Oak	America	B/C	730	4	120	15000	65	12.6
Mogano	America	B	550	4	79	10300	46	8.5
Doussie	Africa	A	800	4	114	16000	62	14.0
Iroco	Africa	A/B	650	4	85	10000	52	12.0
Khaya	Africa	C	520	4	74	9600	44	10.0
Makore	Africa	A	660	4	86	9300	50	11.0
Okoume	Africa	D	440	3	51	7800	27	6.7
Sapeli	Africa	C	650	3	105	12500	56	15.7
Sipo	Africa	B/C	640	3/4	100	12000	53	15.0

NOTES:

1. Area of natural growth
2. Level of natural durability and ease of treatment for impregnation according to Standard EN 350/2
3. Mechanical characteristics with 12% moisture content source Wood Handbook: Wood as an Engineering Material-1987, USDA
   - Ultimate flexural strength, R_f (strength concentrated amidships)
   - Bending modulus of elasticity, E_f (strength concentrated amidships)
   - Ultimate compression strength R_c (parallel to the grain)
   - Ultimate shear strength, R_t (parallel to the grain)

Abbreviations:

Natural durability

A= Very durable
B= durable (maximum permissible thickness for the fabrication of marine plywood 5mm)
C= not very durable (maximum permissible thickness for the fabrication of marine plywood 2.5mm
D= not durable (maximum permissible for the fabrication of marine plywood 2mm)

Ease of treatment for impregnation

1= permeable
2= very nor resistant
3= resistant
4= very resistant

Table 1.5.2: Guide for Selections of Construction Timbers

Species of timber → / Structural item ↓	Douglas	Cedar	Iroko	Latch	Makore	Mahogany	Elm english	White oak	Oak	Sapele	Teak
Keel, hog, sternpost, deadwood			II		II	II	II	II	II	III	I
Stern					II	II	II	II	II	III	I
Bilge stringer	III			II				II		III	I
Beam shelves, clamps, waterways	III		II	II				II	II	III	I
Floors					II	II		II	II		I
Frames grown or web frames				II (2)	II			II (1)	II (1)	III	I
Frames bent frames								II (1)	II (1)		
Planking below waterline	III		II	II		II		II	II	III	I
Planking above waterline	III		II	III		II		II		III	I
Deck planking	II	III	II								I
Beams, bottom girders	II			II	II (2)	II (2)		II (1)	II (1)		I
Brackets vertical				II				II (1)	II		
Brackets horizontal				II				I	I		
Gunwhale, margin planks			II			II		II	II		

NOTES:

1. The timber concerned may be employed either in the natural of in the laminated form
2. The timber may be employed only in the laminated form

Suitability of timber for use:

I = very suitable
II = fairly suitable
III = scarcely suitable

1.6 Scantlings Correction

1.6.1 The structural scantlings apply to timber with the following density δ, in kg/m³, at a moisture content not exceeding 20%:

a. bent frames: δ=720

b. no-bent frames, keel and stem: δ=640

c. shell and deck planking, shelves and clamps, stringers and beams: δ=560

1.6.2 The scantlings given in the following articles may be modified as a function of the density of the timber employed and its moisture content in accordance with the relationship:

$$S_1 = \frac{S}{K}$$

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

where:

S_1 = corrected section (or linear dimension)

S = Rule section (or linear dimension), obtained in accordance with the following articles.

δ_e = density of the timber species (or plywood) used.

δ = standard density of the timber species.

U = standard moisture content percentage (20% for solid timber, 15% for plywood or lamella structures).

U_e = maximum expected moisture content balance for the part considered, in service conditions.

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

Rules and Regulations

for the

Classification and Construction of

SMALL CRAFTS

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CHAPTER 1 STRUCTURAL DESIGN PRINCIPLES

SECTION 1 General

1.1 Definitions

1.1.1 The following definitions are used throughout the present Rules except where specifically defined otherwise.

1.1.2 Length, L, is the distance, in meters, on the summer load line or design waterline from the forward side of the stem to the after side of the rudder post, or the sternpost, or the centre of the rudder stock if there is no rudder post or sternpost. L is to be not less than 96% and need not be greater than 97% of the length on the summer load line or design waterline.

1.1.3 Breadth, B, is the greatest moulded breadth, in meters. For craft of composite construction, breadth B is the greatest moulded breadth excluding rubbing strakes. For multi-hull craft it is to be taken as the sum of the breadths of the individual hulls.

1.1.4 Depth, D, is the moulded depth, measured in meters at the middle of the length L and at the side of the craft, from the top of keel to the top of the freeboard deck beams.

1.1.5 Draught, T, is the draught, in meters, measured at the middle of the length L, from the top of keel to the summer load waterline.

1.1.6 The freeboard deck is the uppermost continuous exposed deck, having permanent means for weathertight closing of all openings, and below which all openings in the craft side are equipped with permanent means for watertight closure.

1.1.7 Bulkhead deck is the uppermost deck, up to which watertight bulkheads extend.

1.1.8 Strength deck is normally the uppermost continuous deck. Other decks may be considered as the strength deck provided that they are structurally effective.

1.1.9 A closing appliance is considered weathertight if it is designed to prevent the passage of water in any sea condition. Generally, all openings at the freeboard deck and all enclosed superstructures are to be provided with weathertight closing appliances.

1.1.10 A closing appliance is considered watertight if it is designed to prevent the passage of water in either direction under a specified head of water. Generally, all openings below the freeboard deck at the craft side and the main bulkheads are to be provided with watertight closing appliances.

1.1.11 A superstructure is defined as an enclosed structure on the freeboard deck, either extending from side to side of the craft, or not fitted inboard of the hull side more than 4% of the Breadth B.

1.1.12 A deckhouse is defined as an enclosed structure above the freeboard deck fitted inboard of the hull side plating more than 4% of the breadth B.

1.1.13 Displacement Δ is the mass displacement of the vessel in the design condition in metric tons.

1.1.14 Block coefficient C_b is given by the formula $C_b = \Delta / (1.025 * L * B * T)$

1.1.15 Gross tonnage is the internal volume of spaces within the craft, as defined by the International Convention on Tonnage Measurements of Ships, 1969.

1.1.16 Significant wave height is the average height of the one-third highest observed wave heights over a given period.

1.2 Internal Subdivision

1.2.1 The hull is to be subdivided into watertight compartments as required for the service of the craft.

1.2.2 All craft with length greater than 15 m are to have, at least, watertight bulkheads as follows:

a. A collision bulkhead.

b. A bulkhead at each end of the machinery space.

1.2.3 For craft with length less than 15 m and craft with the additional class notation YACHT and PATROL, alternative arrangements may be accepted based on special considerations.

1.2.4 The collision bulkhead in all craft is to be positioned at a distance between 0,05L and 0,08L aft from the fore end of length L. For passenger craft, if the collision bulkhead is positioned aft of 0,05L, calculations shall be provided, showing that flooding of the space forward of the collision bulkhead will not result in any part of the freeboard deck becoming submerged, or any unacceptable loss of stability. Alternative arrangements may be submitted for consideration in the case of auxiliary craft. If the craft has a long forward superstructure, the forepeak or collision bulkhead is to be extended weathertight to the next deck above the bulkhead deck. The extension need not be fitted directly over the bulkhead below, provided it is located within the limits specified and the part of the bulkhead deck which forms the step is made effectively weathertight. Special consideration shall be given to the arrangement of collision bulkheads for governmental service craft (Patrol, SAR etc)

1.2.5 In all craft, the stern tube is to be enclosed in a watertight compartment if possible.

1.2.6 Chain lockers located abaft the collision bulkhead and extending into the forepeak tanks, are to be watertight.

SECTION 2 Structural Arrangements

2.1 Scantlings and Structural Calculations

2.1.1 The structure is to be capable of withstanding the static and dynamic loads, which can act on the craft under operating conditions, without such loading resulting in inadmissible stresses and deformation, and loss of watertightness or interfering with the safe operation of the craft.

2.2 Bottom

2.2.1 Single bottoms as well as double bottoms are normally to be longitudinally stiffened in craft built in single skin construction. In craft with sandwich construction, the bottom stiffening will be considered in each individual case. Longitudinals should preferably be continuous through transverse members. At their ends, longitudinals are to be fitted with brackets or to be tapered out beyond the point of support. Longitudinals are to be supported by bulkheads and /or web frames.

2.2.2 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. In the engine room, floors are to be fitted at every frame. In way of thrust bearings, additional strengthening is to be provided.

2.2.3 In craft built in sandwich construction, longitudinal girders may be fitted to support bottom panels. A centre girder is to be fitted for docking purposes, if the external keel or bottom shape does not give sufficient strength and stiffness. If openings are located at the ends of girders, special attention is to be given to shear forces.

2.2.4 Main engines are to be supported by longitudinal girders with suitable local reinforcement, preferably of metallic construction, to take the engine and gear mounting bolts. Rigid core materials are to be applied in all through bolt connections.

2.2.5 Manholes are to be made in the inner bottom, floors and longitudinal girders to provide access to all parts of the double bottom, if possible. The vertical extension of openings is not to exceed one half of the girder height. Exposed edges of openings in sandwich constructions are to be sealed with resin impregnated mat. All openings are to have well-rounded corners.

2.3 Side

2.3.1 Normally, the craft sides are to be longitudinally or vertically stiffened. The continuity of the longitudinals is to be as required for bottom and deck longitudinals respectively.

2.4 Deck

2.4.1 Decks of single skin construction are normally to be longitudinally stiffened. The longitudinals should preferably be continuous through transverse members. At their ends longitudinals are to be fitted with brackets or to be tapered out beyond the point of support.

2.4.2 Bulwark sides shall have the same scantlings as required for a superstructure in the same position. A strong flange is to be fitted along the upper edge of the bulwark. Bulwark stays are to be arranged in line with transverse beams or local stiffening. If the deck is of sandwich construction, solid 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 made near the ends of superstructures.

2.5 Bulkheads

2.5.1 The watertight bulkheads are in general to extend to the freeboard deck. However, the afterpeak bulkhead may terminate at the first watertight deck above the load waterline at draught T.

2.5.2 Watertight bulkheads are, in general, to extend to the bulkhead deck.

2.5.3 Bulkheads are to be spaced at reasonably uniform intervals. Where non-uniform spacing is necessary and the length of a specific compartment is unusually large, the transverse strength of the craft is to be maintained by fitting of web frames, increased framing, etc., and details are to be submitted.

2.5.4 In any case, the number and position of bulkheads are to be so arranged as to comply with the applicable requirements for subdivision, floodability and damage stability, and are to be in accordance with the requirements of the National Authority.

2.6 Superstructures

2.6.1 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.

2.6.2 Sufficient transverse strength is to be provided by means of transverse bulkheads or girders.

2.6.3 At the break of superstructures which have not set-in from the craft’s side, the side plating is to extend beyond the ends of the superstructure and is to be gradually reduced in height down to the deck or bulwark.

2.6.4 In long deckhouses, openings in the sides are to have well-rounded corners. In deckhouses of single skin construction, horizontal stiffeners are to be fitted along the upper and lower edge of large openings for windows. Openings for doors in the sides are to be adequately stiffened along the edges.

2.7 Multihulls

2.7.1 The requirements indicated in this sub-Section are particular for multi-hull craft and are to be applied in addition to the general requirements of this Chapter. The craft is to be considered as one complete structure when determining the minimum geometric summer freeboard. The block coefficient is to be calculated using the actual displacement determined from the hydrostatic data and using the total breadth of the structure and not just a single hull. If, by using normal procedures, the minimum geometric summer freeboard determined is unreasonable for the operation of the craft, special consideration may be given, on a case by case basis, based on the proposed design configuration.

2.7.2 The scantlings and arrangements indicated are for twin hulled craft. Craft with a greater number of hulls will be specially considered on the basis of the Rules. Structural members which contribute to the over-all hull girder strength are to be carefully aligned so as to avoid discontinuities resulting in abrupt variations of stresses and are to be kept clear of any form of openings which may affect their structural performances. Particular care is to be given to the continuity and alignment in way of the end connections of transverse bridging structures.

2.7.3 For craft with multi-hulls linked by cross-deck structures, sufficient clearance is to be provided between the cross-deck structure and water surface to limit impact loads. Where part or all of the cross-deck is intended to provide additional buoyancy to limit craft motion, the loading will be specially considered.

2.7.4 Longitudinal watertight bulkheads are to be arranged within the bridging structures of multi-hull craft to prevent cross flooding and the spread of smoke and flames in the event of fire. The number and distribution of bulkheads will be specially considered dependent upon the structural configuration and size of the craft, but in no case is the number to be less than two for catamarans and four for trimarans. These bulkheads are in general to be positioned in way of the inboard sides of the hulls.

2.7.5 The forefoot and bow regions of fast craft that may be subjected to frequent impacts from flotsam are to be easily accessible for inspection. Access to the forepeak compartments may be provided through the forepeak bulkhead where access would otherwise be impracticable. The aft end regions of all craft are to be easily accessible for inspections. Access may be provided through the aft peak bulkhead or by means of deck hatches or manholes.

2.7.6 Where an engine is fitted within a narrow hull, where engine room temperatures may rise quickly, the ventilation requirements may be increased. Within machinery spaces where space is limited, access is to be provided for inspection.

2.7.7 Superstructures and deckhouses which enclose large flat open areas, that are subjected to racking loads and which may be of several tiers, are to be additionally stiffened with large web frames, partial bulkheads and pillars.

SECTION 3 Closing Arrangements

3.1 General

3.1.1 Downflooding angle is the least angle of heel at which openings in the hull, superstructure or deckhouses, which cannot be closed weathertight, immerse and allow flooding to occur.

3.1.2 Doors, hatches, ventilators, windows, portlights etc. provided with closing appliances which can be secured weathertight, and small openings through which progressive flooding cannot take place, are not considered as downflooding points.

3.1.3 Air pipes are to be fitted with automatic closing appliances, if the openings are immersed at an angle of heel of 40° or the angle of downflooding, if this is less than 40°.

3.2 Double bottom openings

3.2.1 Provision is to be made for the free passage of air and water from all tanks of the double bottom to the air pipes and suctions, taking into account the required pumping rates.

3.2.2 Adequate access is also to be provided to all parts of the double bottom for maintenance, surveys and repairs. Attention is to be given to any relevant International on National regulations regarding the minimum size of access openings.

3.2.3 Manholes and their covers are to be of an approved design, in accordance with a recognized National or International Standard.

3.2.4 The size of openings is not, in general, to exceed 50 per cent of the double bottom depth, unless adequate edge reinforcement is provided.

3.2.5 Manholes, lightening holes and other openings are to be suitably framed and stiffened where necessary.

3.3 Side and stern doors and other shell openings

3.3.1 Side and stern doors are to be so fitted as to ensure the structural integrity of the surrounding structure.

3.3.2 In general, the lower edge of door openings is not to be below the uppermost Load Line. In the opposite case, the arrangement will be specially considered.

3.3.3 Doors are generally to be arranged to open outwards. Inward opening doors will be specially considered.

3.3.4 Doors may be of steel, aluminum alloy or FRP construction. They are to be efficiently connected to the adjoining structure and be of equivalent strength. Doors are to be adequately stiffened and to have proper securing and sealing arrangements. Door openings in the side shell are to have well-rounded corners, and adequate compensation is to be arranged with web frames at sides and stringers or equivalent above and below.

3.3.5 Regarding the closing and securing devices of doors, the following are to be taken into account:

a. Doors are to be fitted with adequate means of closing and securing. Devices are also to be arranged for doors to be secured in the open position.

b. Closing devices are to be simple to operate and easily accessible. The spacing for cleats or closing devices is not to exceed 2,5 m and cleats or closing devices are to be positioned as close to the corners as practicable.

c. Doors with a clear opening area of 12 m^2 or greater are to be provided with closing devices operable from a remote control position. The location of the remote control panel is to be such that the opening/closing operation can be easily observed by the operator or by other suitable means. Means are to be provided to prevent unauthorized operation of the doors and indication is to be provided at each remote control panel to show when the door is open and when fully closed and secured. This indication is to be repeated on the bridge, and means are to be provided on the navigating bridge to indicate leakage via doors. Where hydraulic cleating is applied, the system is to be mechanically lockable in the closed position so that in case of hydraulic system failure, the cleating will remain locked.

3.3.6 For passenger craft, gangway and ports fitted below the margin line are to be sufficiently strengthened. They are to be effectively closed and secured watertight before the craft leaves port, and kept closed during the voyage.

3.4 Hatches on exposed decks

3.4.1 The number and size of hatchways and other access openings are to be kept to a minimum, necessary for the satisfactory operation of the craft.

3.4.2 All openings in decks are to be sufficiently framed, to provide adequate support.

3.4.3 Hatch covers may be of steel, aluminum alloy or FRP construction and they are to be of equivalent strength to the deck on which they are fitted. The thickness of the coamings is to be not less than the Rule thickness for the deck in the positions in which they are fitted. Stiffening of the coamings is to be appropriate to their length and height. The covers are to be adequately stiffened.

3.4.4 Hatch covers are to be weathertight when closed. The means of securing are to be such that weathertightness can be maintained in any sea condition. The covers are to be hose-tested in position under a water pressure of at least 2 bar, at the time of installation.

3.5 Bulkhead openings

3.5.1 Where applicable, the number and construction of watertight doors in bulkheads shall be considered in accordance with the requirements of Chapter X of SOLAS 1974, as amended (High Speed Craft Code).

3.5.2 Watertight doors in bulkheads are to be of equivalent strength to the bulkhead, and capable of being closed watertight. Watertight doors are to be pressure tested from both sides, at the time of installation, for the maximum head of water indicated by any required damage stability calculations or up to the bulkhead deck, whichever is the greater. Indicators are to be provided on the bridge showing whether the doors are open or closed.

3.5.3 Watertight doors are to be efficiently constructed and fitted, and are to be capable of being operated when the craft is listed up to 15° either way.

3.5.4 Doors are to be capable of being operated from both sides of the bulkhead.

3.5.5 No accesses are to be fitted in collision bulkheads. In particular designs where it would be impracticable to arrange access to the forepeak other than through the collision bulkhead, access may be permitted subject to special consideration. Where accesses are provided, the openings are to be as small as practicable and positioned as far above the design waterline as possible. The closing appliances are to be watertight, open into the fore peak compartment and consideration will be given to operation from one side only.

3.5.6 Where subdivision and damage stability requirements apply and where penetration of watertight divisions by pipes, ducts, trunks or other penetrations is necessary, arrangements are to be made in order to maintain the watertight integrity. Ventilators from deep tanks and tunnels passing through tween-decks are to have scantlings suitable for withstanding pressures to which they may be subjected, and are to be made watertight.

3.6 Miscellaneous openings

3.6.1 Manholes and flush scuttles within superstructures other than enclosed superstructures, are to be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers are to be permanently attached.

3.6.2 Openings in freeboard decks other than hatchways, machinery space openings, manholes and flush scuttles are to be protected by an enclosed superstructure, or by a deckhouse or companionway of equivalent strength and weathertightness. Any such opening in an exposed superstructure deck or in the top of a deckhouse on the freeboard deck, which gives access to a space below the freeboard deck or a space within an enclosed superstructure, is to be protected by an efficient deckhouse or companionway.

CHAPTER 2 DESIGN LOADS

SECTION 1 Symbols and Definitions

1.1 Symbols - Units

1.1.1 In addition to the symbols defined in each particular section the following symbols are used in this Chapter:

L= length of the ship, defined in 1.2.2, m,

B= breadth of the ship, defined in 1.2.5, m,

T= draught of the ship, defined in 1.2.6 m,

D= depth of the ship, defined in 1.2.7, m,

Δ= displacement of the ship in tonnes, as defined in 1.2.8,

C_b= block coefficient, defined in 1.2.9,

V= maximum speed in service in m/sec, at maximum displacement,

Fr= Froude number, defined in 1.2.10,

FP= forward perpendicular, defined in 1.2.3,

AP= aft perpendicular, defined in 1.2.4,

WL= water line, defined in 1.2.1,

LCG= longitudinal centre of gravity,

L_{WL}= waterline length, m,

B_{WL}= maximum moulded breadth at the waterline, m,

g= acceleration due to gravity (= 9,80665 m/sec^2).

1.2 Definitions

1.2.1 As a general rule, the waterline is the summer freeboard waterline.

1.2.2 Length L of the ship is the length between perpendiculars. Amidships is defined as the middle of L.

1.2.3 Forward perpendicular is the perpendicular at the intersection of the waterline (when the ship is at rest) with the foremost point of the bow stem.

1.2.4 Aft perpendicular is the perpendicular at the intersection of the waterline (with the ship at rest) with the abaft side of the stern post or the transom.

1.2.5 Breadth B of the ship is the maximum moulded breadth.

1.2.6 Draught T is measured amidships from the top of keel to the waterline.

1.2.7 Depth D is measured amidships from the top of keel to the moulded deck-line at side of the uppermost continuous deck.

1.2.8 Displacement of the ship is the fully loaded displacement in salt water (ρ=1,025t/m^3) on draught T.

1.2.9 Block coefficient C_b is given by the formula:

$$C_b = \frac{\Delta}{1{,}025 \cdot L \cdot B_{WL} \cdot T}$$

1.2.10 Froude number Fr is defined by the formula:

$$Fr = \frac{V}{\sqrt{g \cdot L}}$$

1.2.11 Freeboard deck is the lowest deck above the waterline, weather-tightly closed, which is used to measure the freeboard.

1.2.12 Weather decks are open decks or parts of decks, which are exposed to sea and weather loads.

1.2.13 Bulkhead deck (for passenger ships) is a deck above flooded waterline up to which the watertight bulkheads are carried.

1.2.14 A superstructure is defined as a decked structure on the freeboard deck, extending from side to side of the ship, or inboard of the shell plating at a distance not more than 0,04·B. A deckhouse is a decked structure other than a superstructure.

SECTION 2 Accelerations

2.1 Design vertical acceleration

2.1.1 The formulas for the vertical acceleration given in this section apply to planning craft as defined in Part 1, Chapter 2, SECTION 1, 1.2.4 (b).

2.1.2 The average impact acceleration at the center of gravity of a planning craft operating in irregular head seas is given by the following formula:

$$a^{cg}_{v,1/100} = 1.5 \cdot \tau \cdot \frac{L_{WL} B_C^3}{B_W \Delta}\left(\frac{H_{1/3}}{B_W} + 0.084\right)(5 - 0.1\beta)\frac{V^2}{L_{WL}} 10^{-3}$$

where:

$a^{cg}_{v,1/100}$= Average of the 1/100 highest accelerations at the centre of gravity, in g's,

$H_{1/3}$= Significant wave height, defined in 2.1.3, m,

T= Equilibrium trimming angle, in deg,

β= Deadrise angle, in deg,

B_C= Maximum moulded breadth at the chine in m. In the case of more than one chines, the lower one should be used in the calculations.

B_{WL}= Maximum breadth of hull at LCG at the waterline, in m,

L_{WL}= Waterline length, in m,

V= Ship's speed, in Kn,

Δ= Displacement, in tonnes.

2.1.3 Significant wave height $H_{1/3}$ is the average of the $^1/_3$ highest wave heights. In general, the significant wave height is 20% higher than the "wave height" observed by an experienced person. If no information is available for the significant wave height this is to be taken not less than L/12.

2.1.4 The value of the trim angle depends on the speed of the ship and is provided by the builder. In the case its value is not available it may be taken to be 4 degrees.

2.1.5 Different values of $a^{cg}_{v,1/100}$ may be taken into account if results of model tests or full-scale measurements are available.

2.1.6 The vertical acceleration at the bow of ship, which is defined as the average of the 1/100 highest accelerations at bow, is given by the following formula:

$$a^{b}_{v,1/100} = a^{cg}_{v,1/100} \cdot \left[1 + 1{,}13 \cdot \frac{\left(\frac{L_{WL}}{B_{WL}} - 2{,}25\right)}{Fr}\right]$$

Where:

$a^{b}_{v,1/100}$ = the 1/100 of highest accelerations at the bow, in g's.

2.1.7 The mean vertical acceleration a_v along the length of the ship can be considered to be constant between AP and LCG and linearly varying between LCG and FP.

2.1.8 The average 1/N_{th} highest accelerations $a_{v,1/N}$ is related to the average acceleration a_v by means of the formula:

$$a_{v,1/N} = a_v \cdot (1 + \log_e N)$$

2.1.9 The design vertical acceleration (a_d) at the center of gravity of planning ships, taken as basis for the scantlings, is to be taken as the average of the 1/100 highest accelerations $a^{cg}_{v,1/100}$:

$$a_d = a^{cg}_{v,1/100} = a^{cg}_{v}(1 + \log_e 100) = 5{,}605 \cdot a^{cg}_{v}$$

2.1.10 In order to keep the acceleration at the center of gravity smaller than the design acceleration $a^{cg}_{v,1/100}$ the speed of the ship must remain limited according to the significant wave height $H_{1/3}$. Relationship between allowable speed and significant wave height will be stated in the "Appendix to the Classification Certificate".

2.1.11 For passenger ships the design acceleration at the centre of gravity $a^{cg}_{v,1/100}$ must be limited to 1,0. Installation of an accelerometer at LCG may be required.

2.1.12 The application area of the above formulas is constrained by the following limits:

$$3200 \leq \frac{\Delta}{(0.01 \cdot L)^3} \leq 8000,$$
$$3 \leq \frac{L_{WL}}{B_{WL}} \leq 5,$$
$$3^\circ \leq \tau \leq 7^\circ,$$
$$10^\circ \leq \beta \leq 30^\circ,$$

$$0.2 \leq \frac{H^{\frac{1}{3}}}{B_{WL}} \leq 0.7,$$
$$1.8 \leq \frac{V}{\sqrt{L}} \leq 5.6$$

Special considerations (that is model tests or full scale measurements) should be given for a_v^{cg} when some of the vessels parameters lie outside the above ranges.

SECTION 3 Design loads for planning craft

3.1 General

3.1.1 Design loads given in this section apply to planning craft as defined in Part 1, Chapter 2, SECTION 1, 1.2.4 (b).

3.1.2 Different values for design loads may be taken into account if the builder provides results of model tests, or of full-scale measurements, or of accepted theoretical studies.

3.1.3 For some special cases model tests may be required and may result to an increase of the values of the design loads given in this section.

3.1.4 The load point for which the design pressure given below is to be calculated is defined according to the various strength members as follows:

a) The midpoint for horizontally stiffened plates,

b) Half of the stiffener spacing above the lower support for vertically stiffened plates,

c) The midpoint of span for stiffeners,

d) The midpoint of load area for girders.

3.2 Bottom design pressure

3.2.1 The design pressure on the bottom of the ship is to be taken as:

$$p_b = p_h + 100{,}54 \cdot F \cdot K_d \cdot a_{v,1/100}^{cg} \cdot T$$

where:

p_b= Bottom design pressure, in kN/m²,

p_h= Hydrostatic pressure in, kN/m²,

= ρ·g·T,

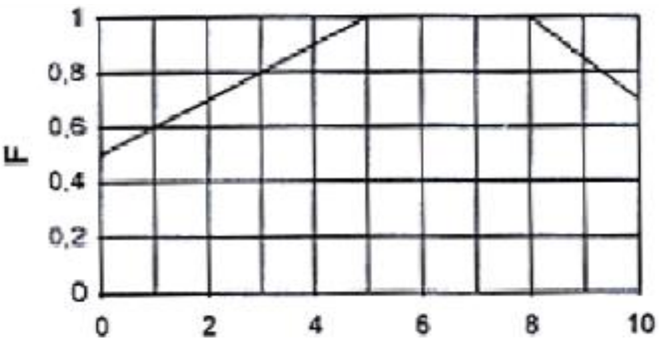
F= Longitudinal pressure distribution factor given in Figure 3.2.1,

K_d= Pressure reduction coefficient given in Figure 3.2.2,

T= Draught of the ship, in m,

$a_{v,1/100}^{cg}$= Design vertical acceleration not to be less than that given in 2.1.2.

Figure 3.2.1: Longitudinal pressure distribution factor, F



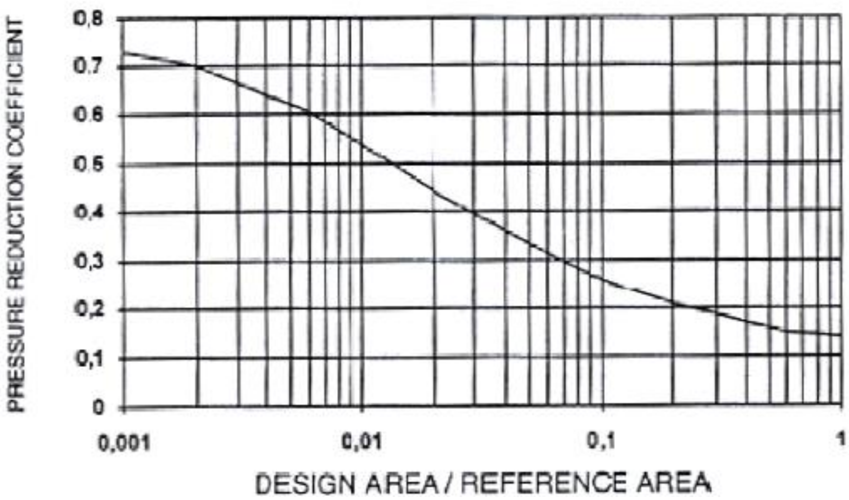
3.2.2 The design area A_D for the considered stiffeners and girders is to be taken as the product:

spacing x span (in m²).

3.2.3 The reference area A_R is defined by the following formula:

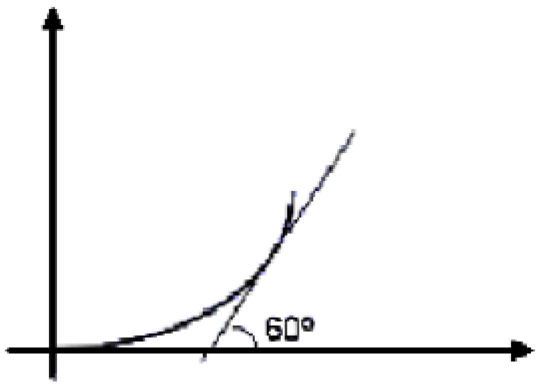
$$A_R = \frac{0{,}7 \cdot \Delta}{T}, m^2$$

Figure 3.2.2: Pressure reduction coefficient K_d



3.2.4 The bottom pressure de fined above is to be applied for the scantlings determination on of the structural l elements within the area extending from the keel to chine or the bilge upper edge. For ships with rounded bilge, the bilge upper edge is defined a s the tangential point of the bilge with an inclined line at slope 60° with the horizontal line (see the Figure 3.2.3).

Figure 3.2.3: Tangential point of the bilge



3.3 Side design pressure

3.3.1 The design pressure on the side of the ship is to be taken as:

a) For load point below the waterline:

$$p_s = 10 \cdot h_0 + S_W \cdot \left(1 - \frac{0{,}2 \cdot h_0}{T}\right)$$

b) For load point above the waterline:

$$p_s = S_W - 5 \cdot h_0$$

with:

$$p_s > p_{s,min}$$

where:

p_s= Side design pressure, in kN/m²,

h_0= Vertical distance in m between the waterline at draft T and the plating lower edge or the frame mid-span, in m,

T= Draught of the ship, in m,

S_w, $p_{s,min}$ are given in the following table:

Table 3.3.1: S_w factor and minimum pressures

	S_w	$p_{s,min}$ (kN/m²)
Fore End	1,0 · L · ad	20
Amidship	0,55 · L · ad	10
Aft End	0,55 · L · ad	10

NOTES:

1. The vertical design acceleration a_d shall be not less than 1 and not greater than 2.
2. Between amidships and fore end of the ship the quantities S_w and $p_{s,min}$ are linearly interpolated.

3.4 Deck Design pressure

3.4.1 The design pressure on the decks of the ship is to be taken as:

$$p_d = a \cdot (S_W - 5 \cdot h_0)$$

with:

$$p_d > 7\ (kN/m^2)$$

where:

p_d= Design pressure on decks in kN/m^2,

= 1,0 for exposed freeboard deck,

= 0,8 for freeboard deck inside superstructures and weather decks above freeboard deck,

h_0= Vertical distance in m between the waterline and the load point on deck,

S_w= as defined in Table 3.3.1.

3.5 Design pressure on superstructures and deckhouses

3.5.1 The design pressure to be considered for the determination of the scantlings of superstructures and deckhouses is not to be less than:

$$p = a \cdot (S_W - 5 \cdot h_0)$$

where:

p= Design pressure for the considered structural element, in kN/m^2,

α= 2,0 for lowest tier of unprotected fronts.

= 1,5 for unprotected superstructure and deckhouse front

= 1,0 for sides of superstructures,

= 0,8 for superstructure decks, sides of deckhouses, aft end of superstructures and deckhouses,

h_0= Vertical distance in m from waterline to the considered load point,

S_w= as defined in Table 3.3.1.

3.5.2 When the calculated value of the above pressure is negative, take into consideration the minimum value of the pressure.

3.5.3 The minimum values of p to be considered are:

- for the lowest tier of unprotected fronts p_{min}= 15kN/m^2
- for unprotected superstructures and deckhouse fronts elsewhere p_{min}= 10kN/m^2
- for other sides and decks p_{min}= 7kN/m^2

3.6 Design pressure on bulkheads

3.6.1 The design pressure on watertight bulkheads is to be taken as:

$$p = \rho \cdot g \cdot h$$

with:

$$p > 15\ kN/m^2$$

Where:

p= design pressure, in kN/m^2,

ρ= 1,025 t/m^3,

h= vertical distance, in m, from the load point to the top of the bulkhead or the flooded line.

As load point we consider the plating lowest edge or the midpoint of the stiffener span.

3.6.2 The design pressure on a deck or inner bottom, which forms part of the watertight bulkhead, is to be taken at least equal to that for the bulkhead at the same level.

3.6.3 The design pressure on bulkheads in liquid tanks is to be taken as the greatest of:

$$p = \rho \cdot (g + a_v) \cdot h,$$
$$p = \rho \cdot g \cdot (h + 0{,}5 \cdot h_s),$$
$$p = \rho \cdot g \cdot (h + 1{,}5),$$

where:

p= Design pressure, in kN/m^2,

a_v= Vertical acceleration at the considered point as given in 2.1.7,

h_s= Vertical distance, in m, between the load point and the top of the air pipe,

h= Vertical distance, in m, between the load point and the top of tank.

3.7 Loads from heavy units

3.7.1 The vertical forces acting on structural elements and coming from heavy units as cargo, equipment etc. are to be taken as:

$$P = (g + a_v) \cdot M,$$

Where:

P= vertical force, in kN,

M= mass of unit, in t,

a_v= Vertical acceleration at the considered point given in 2.1.7.

3.7.2 Especially for engine and boiler seatings etc. see also the Requirements at Part 3 – Chapter 5 – Paragraph 7.12 where dynamic effects are taken into consideration.

SECTION 4 Design loads for displacement craft

4.1 General

4.1.1 Design loads given in this section apply to displacement craft as defined in Part 1, Chapter 2, SECTION 1, 1.2.4 (a).

4.1.2 Different values for design loads may be taken into account if results of model tests or of full scale measurements or of accepted theoretical studies are provided by the builder.

4.1.3 For some special cases model tests may be required and may result to an increase of the values of the design loads given in this section.

4.1.4 The load point for which the design pressure given below is to be calculated is defined according to the various strength members as follows:

a) The midpoint for horizontally stiffened plates.

b) Half of the stiffener spacing above the lower support for vertically stiffened plates.

c) The midpoint of span for stiffeners.

d) The midpoint of load area for girders.

e) The plating lowest edge or the midpoint of the stiffener span for bulkheads.

4.1.5 For ships with service restrictions the S_w factor used in this Section may be reduced according to the Error! Reference source not found.**:**

Table 4.1.1: Reduction to S_w due to service restrictions

Service notation	Reduction (%)
Costal service	20
Extended protected waters service	40
Protected waters service	50
<u>NOTE:</u> 1. In the case of 'Specified route service' or 'Specific operating area service' notations the reduction will be specially considered.	

4.1.6 The minimum pressure values, in KN/m², are given in Table 4.1.2.

Table 4.1.2: Minimum pressure values

	Protected waters service	Extended protected waters service	Costal service	Unrestricted
Bottom	12	12	12	12
Sides	4	5	6,5	8
Weather deck	3,5	4	5	6
Lowest tier of Unprotected fronts	4	5	6,5	8

4.2 Bottom design pressure

4.2.1 The design pressure on the bottom of the ship is to be taken as:

$$p = 10 \cdot h_0 + S_W \cdot \left(K_s - \frac{0{,}2 \cdot h_0}{T}\right)\text{, but not less than } 12\ \mathrm{kN/m^2}.$$

Where:

p= bottom design pressure, in kN/m^2,

S_W= 0.8·L

K_s= distribution factor as follows:

= 0,75 between Aft End and Amidships

= 1,4 at Fore End,

= in intermediate positions the factor Ks is linearly interpolated,

h_0= vertical distance between the waterline at draught T and the load point, in m,

T= draught of the ship, in m.

4.3 Side and deck design pressure

4.3.1 The design pressure on the side and decks of the ship is to be taken as follows:

a) For load points below the waterline:

$$p = 10 \cdot h_0 + S_W \cdot \left(K_s - \frac{0{,}2 \cdot h_0}{T}\right)\text{, but not less than } p_{min}$$

b) For load points above the waterline:

$$p = a \cdot K_s \cdot (S_W - 5 \cdot h_0)\text{, but not less than } p_{min}$$

Where:

p= design pressure, in kN/m²,

K_s, S_W = as defined in 4.2.1,

h_0= vertical distance between the waterline at draught T and the load point, in m,

T= draught of the ship, in m,

α= 1,0 for the side plating and the exposed freeboard deck,

= 0,8 for the freeboard deck inside superstructures and weather decks above freeboard deck.

4.4 Design pressure on superstructures and deckhouses

4.4.1 The design pressure on superstructures and deckhouses is not to be less than:

$$p = a \cdot K_s \cdot (S_W - 5 \cdot h_0),$$

where:

p= design pressure for the considered structural element, in kN/m²,

α= 2,0 for lowest tier of unprotected fronts,

= 1,5 for unprotected superstructure and deckhouse front,

= 1,0 for sides of superstructures,

= 0,8 for superstructure decks, sides of deckhouses, aft end of superstructures and deckhouses,

h_0= vertical distance from waterline at draught T to the considered load point, in m,

S_w= as defined in 4.2.1.

4.4.2 Please note that if the calculated pressure from the above formula is negative, take into consideration the minimum value of the pressure.

4.5 Design pressure on bulkheads

4.5.1 The design pressure on watertight bulkheads is to be taken as:

$$p = \rho \cdot g \cdot h,$$

where:

p= design pressure in kN/m^2,

ρ= 1,025 t/m^3,

h= vertical distance, in m, from the load point to the top of the bulkhead or the flooded line.

As load point we consider the plating lowest edge or the midpoint of the stiffener span.

4.5.2 The design pressure on a deck or inner bottom which forms part of the watertight bulkhead is to be taken at least equal to that for the bulkhead at the same level.

CHAPTER 3 LONGITUDINAL STRENGTH

SECTION 1 General

1.1 Application

1.1.1 For ships of ordinary hull form with length less than 50 m, longitudinal strength requirements are normally satisfied for scantlings obtained from local strength calculations.

1.1.2 In some cases, longitudinal strength calculations may be required at PHRS discretion, dependent upon the proposed ship loading condition. In these cases, longitudinal strength is to be calculated as described in the sequel.

1.1.3 In addition to the symbols defined in each particular section, the symbols defined in Part 3, Chapter 2, SECTION 1 will be used in this Chapter.

1.1.4 For ships the class of which is valid only for a restricted range of service, the wave bending moments and the wave shear forces as calculated from 2.2, 2.3, 2.4 may be reduced as follows:

a) Coastal service by 25%

b) Extended protected waters service by 30%

c) Protected waters service by 40%

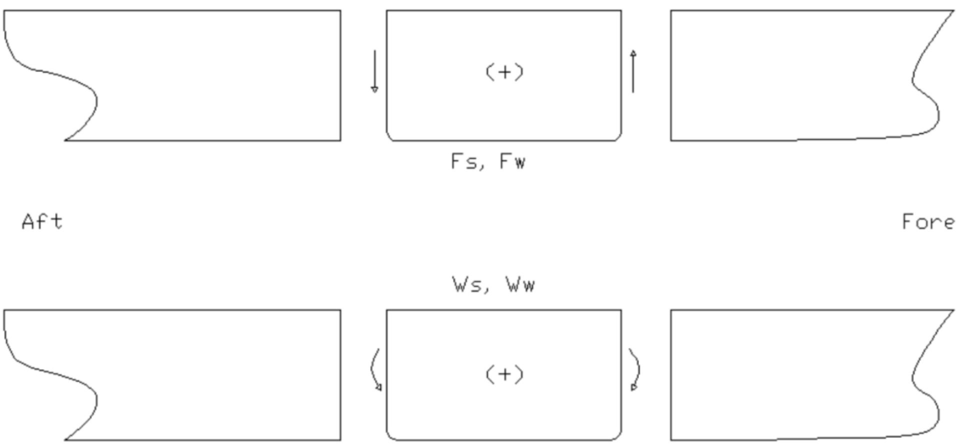
In the case of 'Specified route service' or 'Specific operating area service' notations, the reductions in the wave bending moments and the wave shear forces will be specially considered.

SECTION 2 Hull girder loads

2.1 Sign convention

2.1.1 The sign convention of the bending moments and shear forces is shown in Figure 2.1.1.

Figure 2.1.1: Sign convention



2.2 Still-water bending moment and shear force

2.2.1 The still-water bending moment M_S, and shear force F_S, given by the following formulae may be used within 0,4L amidships:

$$M_S = 0{,}075 \cdot SM_O$$

$$F_S = 0{,}8 \cdot F_W$$

where:

M_S= still-water bending moment, in kNm,

SM_O= required section modulus of the midship section as defined in 3.1.1,

F_W= wave-shear force F_W (+) or F_W (-), whichever is greater, as defined in 2.4.1.

2.3 Wave bending moments

2.3.1 The wave bending moments M_W at each section along the ship length are given by the following formulae:

$$M_W(+) = +0{,}3 \cdot M \cdot C_W \cdot L^2 \cdot B \cdot C_b\ , \qquad for\ positive\ moment\ (hogging)$$

$$M_W(-) = -0{,}15 \cdot M \cdot C_W \cdot L^2 \cdot B \cdot (C_b + 0{,}7) \cdot (0{,}8 + 1{,}5 \cdot F_r)\ , \qquad for\ negative\ moment\ (sagging)$$

where:

C_W= 0,08L,
L= length of the ship in m,
B= breadth of the ship in m,
C_b= block coefficient,
Fr= Froude number,
M= distribution factor as follows:
= 1,0 between 0,4L and 0,8L from A.P.,
= 0 at A.P. and F.P.,
in intermediate positions the factor M

2.3.2 For planning craft where Fr>1,0, the wave bending moment will be subject to special consideration due to dynamic effects. In this case, a slamming pressure is acting on an area at the bottom of the ship equal to the reference area A_R defined by:

$$A_R = \frac{0{,}7 \cdot \Delta}{T}$$

Where:

A_R= reference area, in m²,
Δ= displacement of the ship, in tonnes,
T= draught of the ship, in m.

This area is to be considered with its center at LCG of the ship. The hull beam is to be considered out of water with the actual weight distribution along it.

2.3.3 The wave bending moment due to slamming M_{sl} at each section along the ship length may be assumed to be given by the formula:

$$M_{sl}(+) = M \cdot \frac{\Delta}{2} \cdot (1{,}0 + a_d) \cdot g_o \cdot \left(m - \frac{A_R}{4 \cdot B_C}\right), \qquad for\ positive\ moment\ (hogging)$$

Where:

M_{sl}= wave bending moment due to slamming, in kNm,
Δ= displacement of ship, in tonnes,
a_d= design vertical acceleration at LCG in g's, defined in Part 3, Chapter 2, SECTION 2, 2.1.9,
m= mean lever arm in m, defined as follows:
$m = \frac{M_{AF}+M_{FR}}{\Delta}$, where:
M_{AF}= moment about midship perpendicular of the displacement of the aft half of the ship, in tm,
M_{FR}= moment about midship perpendicular of the displacement of the fore half of the ship, in tm,
m= 0,25L, if not known,
Bc= maximum moulded breadth at the chine, in m,
M= distribution factor as defined in 2.3.1.

2.3.4 Different values based on accepted theoretical studies may be accepted subject to the approval of the Society.

2.4 Wave shear forces

2.4.1 The wave shear forces F_W at each section along the ship length are given by the following formulae:

$$F_W(+) = 0{,}3 \cdot F_1 \cdot C_W \cdot L \cdot B \cdot (C_b + 0{,}7)\,, \qquad for\ positive\ shear\ force,$$
$$F_W(-) = -0{,}3 \cdot F_2 \cdot C_W \cdot L \cdot B \cdot (C_b + 0{,}7)\,, \qquad for\ negative\ shear\ force$$

where:

L, B, C_b,C_W= as defined in 2.3.1,
F_W= wave shear force, kN,
F_1= distribution factor:
= 0 at A.P. and F.P.,
= 0,7 between 0,2L and 0,6L from A.P.,
= 1,2 between 0,7L and 0,85L from A.P.,
= in intermediate positions the factor F_1 is linearly interpolated,
F_2 = distribution factor:
= 0 at A.P. and F.P.,
= 0,95 between 0,2L and 0,3L from A.P.,
= 0,7 between 0,4L and 0,85L from A.P.,
= in intermediate positions the factor F_2 is linearly interpolated.

2.4.2 For planning craft where Fr>1,0, the wave shear force due to slamming F_{sl} may be related to the wave bending moment given in 2.3.3 as follows:

$$F_{sl} = \frac{4 \cdot M_{sl}}{L}$$

where:

F_{sl}= shear force due to slamming, in kN,

M_{sl}= bending moment as defined in 2.3.3.

SECTION 3 Hull girder strength

3.1 Hull girder bending strength

3.1.1 The section modulus to the strength deck and to the keel of the midship section is not to be less than the greatest of the following values:

$$SM_O = C_W \cdot L^2 \cdot B \cdot (C_b + 0{,}7)$$
$$SM = |M_S + M_{Wave}|/\sigma \cdot 10^{-3}$$

where:

SM_o,SM= required section modulus in cm^3,
L, B, Cw, C_b= as defined in 2.3.1,
M_S= maximum still water bending moment, in kNm, calculated according to 2.2.1,
M_{Wave}= wave-induced bending moment M_W or M_{sl}, whichever is greater, as defined in 2.3.1 and 2.4.1, respectively,
σ= For constructions of FRP or wood minimum ultimate tensile or compressive strength whichever is less in N/mm^2, verified by approved test results in accordance with the requirements of Part 2.
= 175 / k N/mm^2 for steel or aluminum constructions.
K= material factor
= 1,0 for ordinary hull structural steel
= 0,78 for steel with minimum upper yield point 315 N/mm^2
= 0,72 for steel with minimum upper yield point 355 N/mm^2
= 235 / σ_{al} for aluminum constructions
σ_{al}= guaranteed minimum 0,2% proof stress of the alloy in the welded condition, in N/mm^2.

3.1.2 In general all members which are continuous or effectively developed within 0,4L amidships and gradually tapered beyond the 0,4L may be included in the section modulus calculation. The section modulus to the strength deck or to the keel is obtained by dividing the moment of inertia of the section by the vertical distance from the neutral axis to the moulded deck line at side amidships, or to the base line, respectively.

3.1.3 For ships having wide and/or long hatch openings or where a relatively large portion of the deck is open, calculations of combined stresses may be required. In this case, the section modulus may be required to be increased.

SECTION 4 Twin hull girder loads

4.1 General

4.1.1 The transverse strength of twin hull connecting structure may be analyzed for moments and forces specified below.

4.1.2 Design forces and moments given in 4.2 and 4.3 are to be used unless other values are verified by model tests or full scale measurements or if similar structures have proved to be satisfactory in service.

4.1.3 Superstructure is normally not to be included in the structure giving transverse strength.

4.2 Vertical bending moment and shear force.

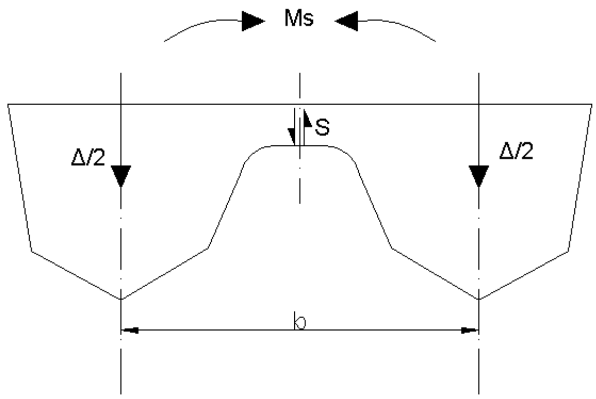
4.2.1 For craft with $\left(V/\sqrt{L} \geq 3\right)$ the twin hull transverse bending moment may be assumed to be:

$$M_S = \frac{\Delta \cdot a_d \cdot b}{s}, \qquad kNm$$

where:

Δ= displacement of the ship, in tonnes,
a_d= design vertical acceleration as given in Part 3, Chapter 2, SECTION 2, 2.1.9,
b= transverse distance between the centerlines of the two hulls,
s= factor given in Table 4.2.1.

Figure 4.2.1:



4.2.2 For craft with $\left(V/\sqrt{L} < 3\right)$ the twin hull transverse bending moment may be assumed to be the greater of:

$$M_S = M_{SO} \cdot \left(1 + \frac{a_d}{g_o}\right), \qquad kNm$$
$$M_S = M_{SO} + F_y \cdot (z - 0{,}75 \cdot T), \ \ kNm$$

Where:

M_{SO}= still water transverse bending moment, in kNm.
a_d= design vertical acceleration as given in Part 3, Chapter 2, SECTION 2, 2.1.9,
T= draught of the ship, in meters.
F_y= horizontal split force on immersed hull,

$0{,}1 \cdot L^2 \cdot C_1 \cdot C_2 \cdot \left(1 + 0{,}1 \cdot \frac{V}{\sqrt{L}}\right) \cdot \left(53 - \frac{L}{0{,}5 \cdot B_{WL}}\right), kN,$ where:

$C_1 = 1{,}6 - \frac{6}{\sqrt{L}}$
$C_2 = \frac{70}{\left(\frac{L}{T}\right)^{1{,}5}}$
L= length of the ship, in meters,
T= draught of the ship, in meters,
B_{WL}= the net sum of the waterline breadths, in meters,
z= height, in m, from base line to neutral axis of cross structure.

4.2.3 The vertical shear force in centerline between twin hull may be assumed to be:

$$S = \frac{\Delta \cdot a_d}{q}, kN$$

where:

a_d= design vertical acceleration as given in Part 3, Chapter 2, SECTION 2, 2.1.9,
Δ= displacement of the ship, in tonnes,
q= factor given in Table 4.2.1.

Table 4.2.1: s and q factors

Service restriction	s	q
Extended protected waters service	8	6
Specified costal service	7,5	5,5
Unrestricted	4	3

4.3 Twin hull torsional moment

4.3.1 Hull torsional moment of twin hull may be assumed to be:

$$M_t = \frac{\Delta \cdot a_d \cdot b}{4}, kNm$$

where:

a_d= design vertical acceleration as given in Part 3, Chapter 2, SECTION 2, 2.1.9,
Δ= displacement of the ship, in tonnes,
b= distance, in m, between the two hull centerlines.

CHAPTER 4 HULL CONSTRUCTION - FRP

SECTION 1 Structural Details

1.1 Laminates

1.1.1 Structural continuity is to be maintained and where changes in thickness or structural section occur, they are to be gradual to prevent notches, hard spots and other structural discontinuities. The ends of all internal members are to provide end fixity and load transmission to the supporting member; departures from this may be considered where the alternative structure has equivalent strength.

1.1.2 A gradual taper is to be used for all changes in laminate thickness. Where the construction changes from sandwich laminate to a solid laminate, the thickness of the core material is, in general, to be reduced by a gradual taper of not less than 2:1.

1.1.3 Access and lightening holes with suitable radius corners are to be arranged as necessary and clear of areas of load concentration or high stresses. Their depths and lengths are generally not to exceed, respectively, 0,5 and 0,75 the depths of the members. Air and timber holes are to be arranged to eliminate air pockets and avoid any accumulation of water or other liquids. In general, their radius is not to be less than 40 mm and not more than $1/3$ the depth of the member. All exposed edges of FRP single-skin laminates are to be sealed with resin. Edges of sandwich panels and edges of holes in sandwich panels are to be sealed with resin-impregnated mat. Ferrules installed in sandwich panels or stiffeners for drains or wire penetrations are to be set in bedding compound. All hatch openings are to be supported by a system of transverse and longitudinal stiffeners.

1.1.4 Discontinuities and hard points in the structure are to be avoided, and where the strength of a stiffening member is impaired by any attachment of fittings, openings, drainage arrangements, etc., compensation is to be provided.

1.1.5 Where items are prefabricated outside the mould, they are to be connected by boundary angles formed by layers of reinforcement, structural fillets or other approved method. Where structural fillets are proposed, the scantlings and arrangements will be specially considered.

1.1.6 Polyester, vinylester or epoxy resin may be used in bonded joints, provided that the joint is so designed that the resin bond is in shear. The contact area is to be as large as practicable and the surfaces are to be suitably prepared in accordance with the resin manufacturer’s instructions.

1.1.7 The submitted plans are to clearly define the laminate sequence at corner joints. In general, corner laminates are to be boxed and all cuts are to be alternately staggered to avoid a fault line. At corner joints, vertical and horizontal laminates are to be laid alternately and butts are to be staggered accordingly.

1.1.8 The submitted plans are to clearly define the details of scarfed joints. In general, scarfs are not to be steeper than a 12:1 taper. Scarf joints may be either ground or stepped. Where single taper scarf joints are proposed, a sealing laminate is to be provided, details of which are to be submitted. Where stepped joints are proposed, care is to be taken to ensure that over-cutting does not occur. All joints are to be arranged so that they can be reinforced internally to maintain structural continuity of the laminate.

1.1.9 Lap joints may be bolted or adhesively bonded, or both. They may be single or double lapped dependent upon the specific application.

1.1.10 Where tray mouldings form part of the integral structure of the craft, full details are to be indicated on the submitted plans. Information regarding tolerances is to be presented together with details of all adhesives and proposed bonding-in techniques. Particular attention is to be given to the design so as to maintain the structural continuity of the webs of any stiffening members.

1.1.11 Chine details are to be clearly indicated on the submitted plans. Spray rails may form part of the structural laminate or may be installed as a laminated or bolted appendage. Where the chine is a laminated appendage, provision is to be made for a sacrificial ply at which failure may occur without undue damage to the remaining structure of the hull. Sandwich structures are to be returned to single skin laminates at chine rails, unless agreed otherwise on the approved construction plans. Chine rails are to be infilled and over laminated on the inner surface of the hull. Additional reinforcement is to be laminated into the chine area.

1.1.12 Reinforcements are to be arranged to maintain continuity of strength throughout the laminate. Joints in each layer of reinforcement are, in general, to be overlapped. The length of the overlap is dependent upon the type of reinforcement, but is not to be less than 50 mm. The positions of the joints in the laminate are to be staggered, in general by 150 mm, to maintain as near uniform laminate thickness as practicable. Tests may be required to demonstrate continuity of strength when bi-directional, multi-axial or cross-plied reinforcements are used.

1.1.13 As an alternative to overlapping, as required by 1.1.12, individual consideration will be given, on the basis of test results, to partial butting of reinforcements manufactured with a selvedge. For such reinforcements the selvedge tails are to be laid on top of each other to provide continuity. Butts in the same vertical plane are to be separated by not less than five passing plies.

1.1.14 Areas of single skin structure in way of the attachment of fittings or equipment are, in general, to be increased in thickness by not less than 50%, with the additional layers staggered beyond the extremities of the surrounding stiffening.

1.1.15 The design of the structure in way of the attachment of fittings or equipment in sandwich structures is to be such that the induced loads can be transmitted into the surrounding structure by bending as opposed to shear. The areas are in general to take the form of suitably reinforced single skin areas, with the additional layers of reinforcement staggered out onto the surrounding inner and outer skins.

1.1.16 Laminate overlapping and staggering arrangements may require to be tested at the discretion of the Surveyor.

1.1.17 Laminates may be fastened mechanically, provided that the fastenings are of a corrosion resistant metal and are spaced and positioned so as not to impair the efficiency of the joint. The fastenings are to be of an acceptable type and, where washer plates are used, they are to be of a compatible material. The edges of the laminates and the fastening holes are to be sealed.

1.1.18 Where plywood and timber members are to be matted on to, or encapsulated within, the laminate, the surface of the wood is to be suitably prepared prior to bonding.

1.2 Stiffeners

1.2.1 Stiffeners, frames, girders, deck beams, bulkhead stiffeners, etc. used to support FRP panels may be entirely of FRP, FRP laid over nonstructural cores or forms, or composites of FRP and other approved structural materials, such as plywood or wood.

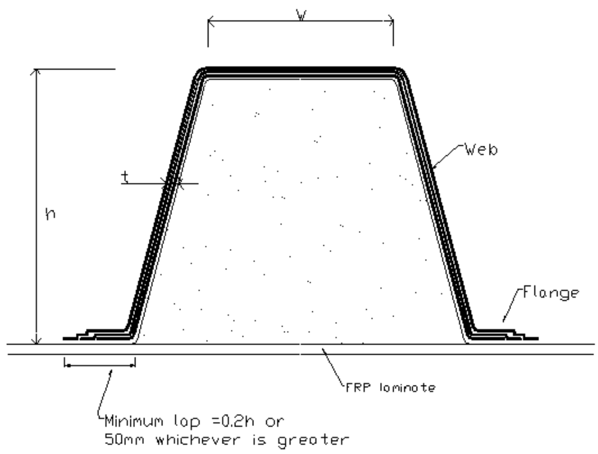
1.2.2 Stiffeners without cores or with cores other than Balsa wood and PVC, are to conform to Figure 1.2.1 and the thickness of the crown and web of the stiffeners is to be not less than obtained from the following equations:

$$t_i = \frac{w}{20}, (mm)$$
$$t = \frac{h}{30}, (mm)$$

where:

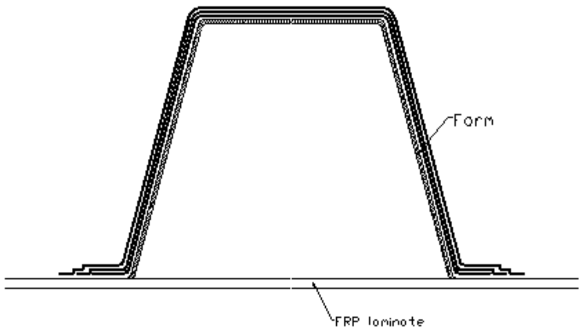
t_i = thickness of the stiffener crown
t = thickness of stiffener web
w = width of stiffener crown
h = height of stiffener webs

Error! Reference source not found.**Figure 1.2.1: Proportions of Stiffeners**



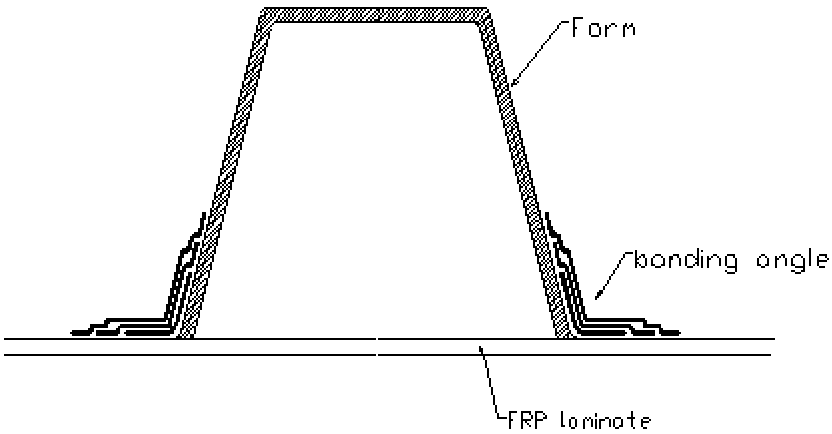
1.2.3 Hat section stiffeners constructed by laying FRP over premolded FRP forms are to conform to Figure 1.2.2 and the above equations. The premolded forms may be considered structurally effective if their physical properties are at least equal to those of the overlay laminates.

Figure 1.2.2: Pre-Molded Stiffeners



1.2.4 Premolded stiffeners bonded to the laminates with FRP angles, flanges or tapes are to conform to Figure 1.2.1 and Figure 1.2.3 and the above equations. The thickness of each bonding angle flange or tape is to be not less than the thickness of the webs of the stiffener, and the length of the legs of the bonding angle, flange or tape are given in 1.1.12. Joints in premolded stiffeners are to be scarphed and spliced or otherwise reinforced to maintain the full strength of the stiffeners.

Figure 1.2.3: Bonding Angles



1.2.5 Girders and longitudinal frames are to be continuous through floors and web frames. Except in way of integral tank end bulkheads, girders and longitudinal frames are also to be continuous through bulkheads. Where such members are intercostal, attention is to be given to minimizing structural discontinuities. The laps of the connections onto the supporting structure are to be not less than the overall widths of the members including flanges, and the thickness of the connections are to be not less than the thickness of the structural member flanges or tapes.

1.2.6 Moulding on the hull of reinforcing elements is to be undertaken before the laminate is fully cured and in the shortest possible lapse of time after moulding of the hull, to avoid internal strains by differential shrinkage and a poor connection of joined surfaces.

1.2.7 Addition of moulded working elements to the hull during the hull construction is acceptable, provided that these elements, when connected to the hull, are at the same state of maturity of resins and before complete curing of the laminate.

1.2.8 Moulding of reinforcing elements on the hull already cured and addition by gluing of rigid elements separately moulded and cured can be carried out, if these processes are used with a preparation of surfaces to allow adherence. The connection is then to be carried out so that the possible deformations do not involve a too large straining of parts. The surface of contact has to be as wide as possible.

1.2.9 Mechanical connections by bolts, rivets or screws crossing through the laminate, used for fastening wooden or metallic elements or for fastening of superstructure or equipment are to be made in order to avoid excessive local stresses in the laminate. They are, in no case, to go against the tightness of this laminate.

1.2.10 As a general rule, it is necessary to recreate the protection of the laminate in the holes and openings made for the passage of connections.

1.2.11 Attachments, by means of studs or other arrangements implying insertion of metallic pieces in the laminate thickness during moulding, are to be avoided. Wood insertions are acceptable, if the wood is entirely sealed, so that any increase of moisture is practically prevented.

1.3 Fittings, Flanges & Bondings

1.3.1 Deck fittings such as cleats and chocks are to be bedded in sealing compound or gasketed, through-bolted, and supported by either oversize washers, or metal, plywood or wood backing plates. Where washers are used, the laminate in way of the fittings is to be increased at least 25% in thickness.

1.3.2 Generally, all through-hull penetrations are to be formed by solid FRP laminates. When sandwich construction is used for the hull, the core material is to be completely sealed off from the through hull penetration. All through hull penetrations are to be taped on both sides of the penetration.

1.3.3 Boundary Angles, Flanges or Tapes

a) FRP to FRP:

At the end connections of sandwich laminates the core shear strength is to be effectively developed. The thickness of each boundary angle, flange or tape having similar strength to the members being connected is to be not less than obtained from the following:

1. Single-skin to single-skin: One half the thickness of the thinner of the two laminates being joined.
2. Sandwich to sandwich: The greater of the mean thickness of the skins of the sandwich panels being attached.

3. Sandwich to single skin: Either one half the thickness of the single skin laminate or the mean thickness of the sandwich panel being attached, whichever is less.

The thickness of each FRP-FRP boundary angle is also to be not less than obtained from the following equation:

$$t = 0{,}105L + 1{,}11\ mm,$$

Where:

L = Length, m

The width of each flange, not including end taper is to be not less than 10 times the thickness given above and including the end taper, 13 times the thickness given above, and in general not less than 50 mm. Typical arrangements are shown in Figure 1.3.1 and Figure 1.3.2.

Figure 1.3.1: Sandwich to Sandwich connection

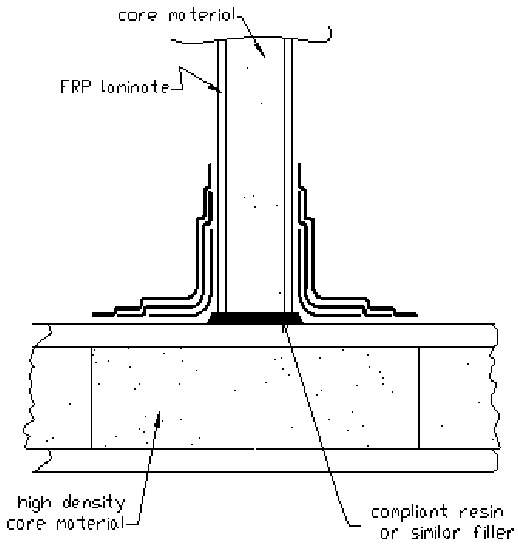
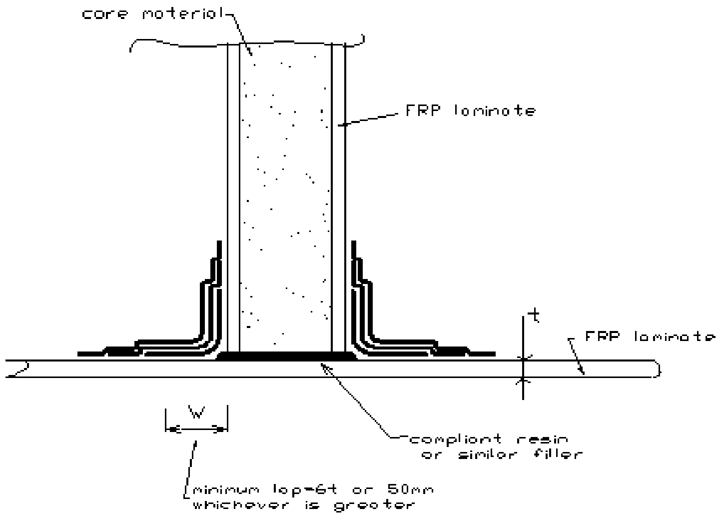


Figure 1.3.2: Sandwich to Single-Skin connection



b) Plywood or Wood to FRP

Plywood bulkheads are to be bedded in foam, a slow curing polyester putty, a micro-balloon and resin mixture, or other approved material. The boundary angles are to be at least equal in thickness to one-half the thickness of the laminate. The width of each flange is given above, for FRP to FRP connections. Typical arrangements are shown in Figure 1.3.3 and Figure 1.3.4.

Figure 1.3.3: Plywood or wood to FRP connection

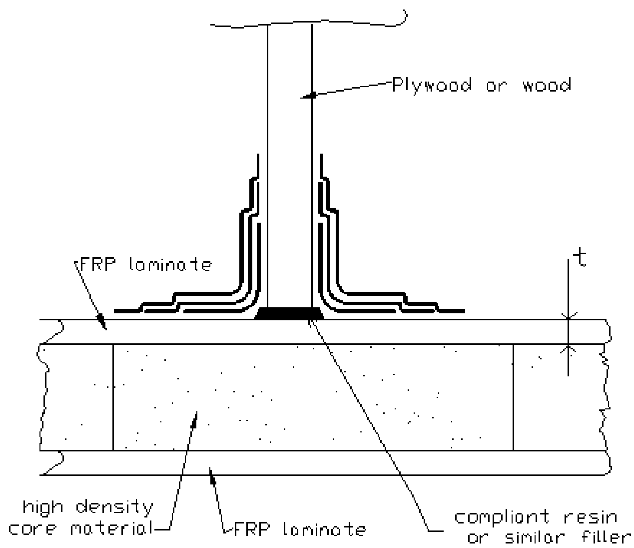
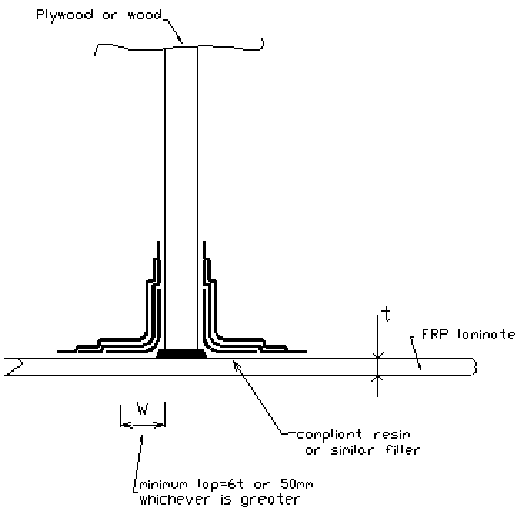


Figure 1.3.4: Plywood or wood to FRP connection



1.4 Shell Details

1.4.1 Plate keels are to meet the requirements in Figure 1.4.1. They are to be adequate for docking loads, which are provided by the designer. Keelsons are to meet the requirements in Figure 1.4.2 and Figure 1.4.3. Chines, spray rails and transoms are to meet the requirements in Figure 1.4.4, Figure 1.4.5, Figure 1.4.6, Figure 1.4.7, Figure 1.4.8 and Figure 1.4.9. Engine foundations are to be of thickness and widths appropriate to the holding down bolts. They are to be set in mat or resin putty to assure uniform bearing against the girders, and are to be bolted through the webs of the girders. Acceptable typical engine foundations are shown in Figure 1.4.10 and Figure 1.4.11.

Figure 1.4.1: Plate keel

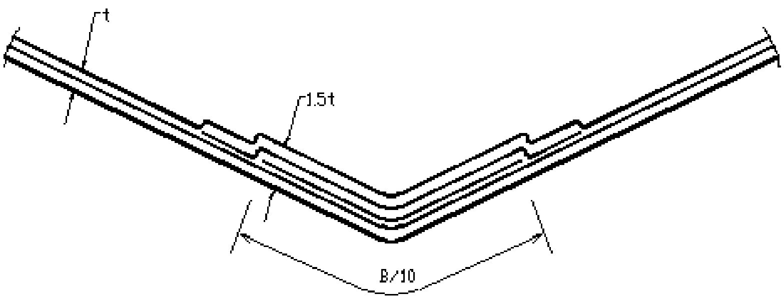


Figure 1.4.2: Keelson

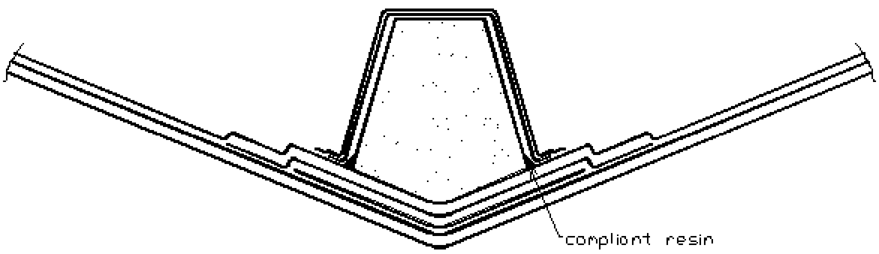


Figure 1.4.3: Keelson

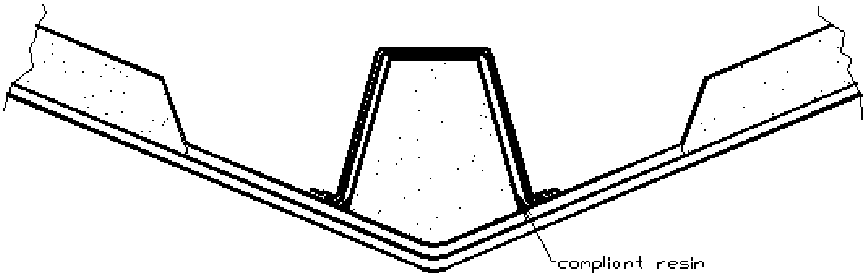


Figure 1.4.4: Chine detail

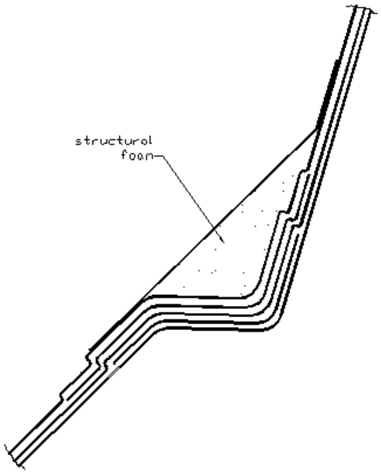


Figure 1.4.5: Chine detail

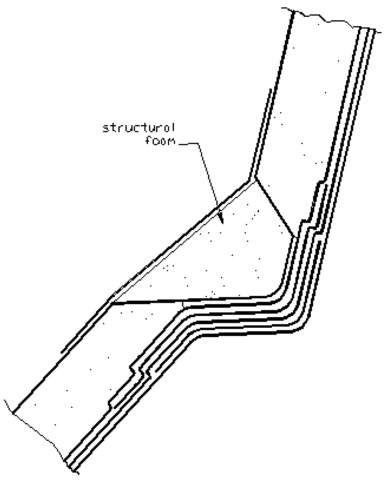


Figure 1.4.6: Spray Rail

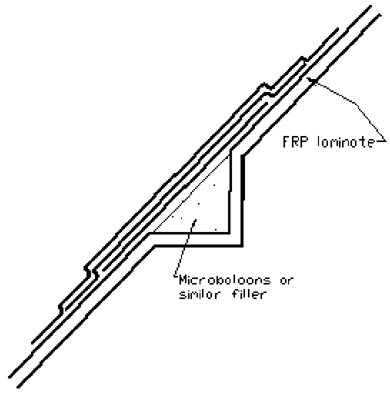


Figure 1.4.7: Spray Rail

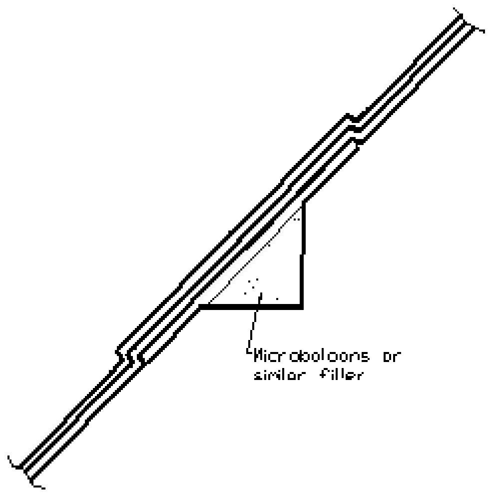


Figure 1.4.8: Transom

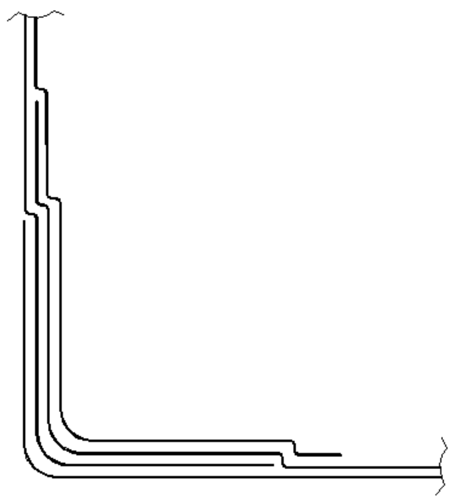


Figure 1.4.9: Transom

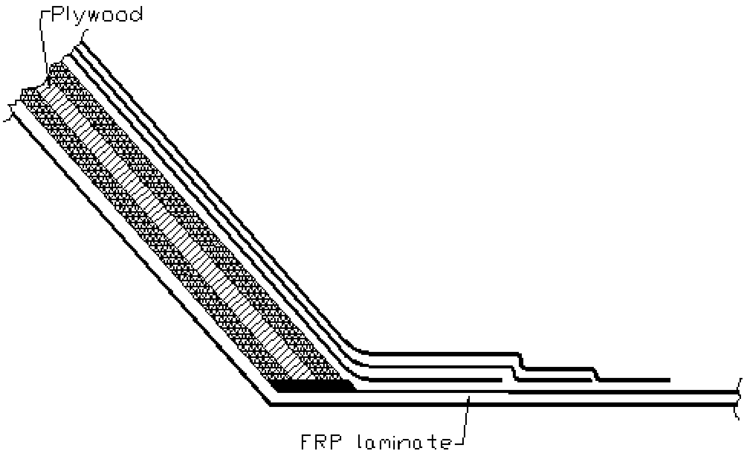


Figure 1.4.10: Engine Foundation

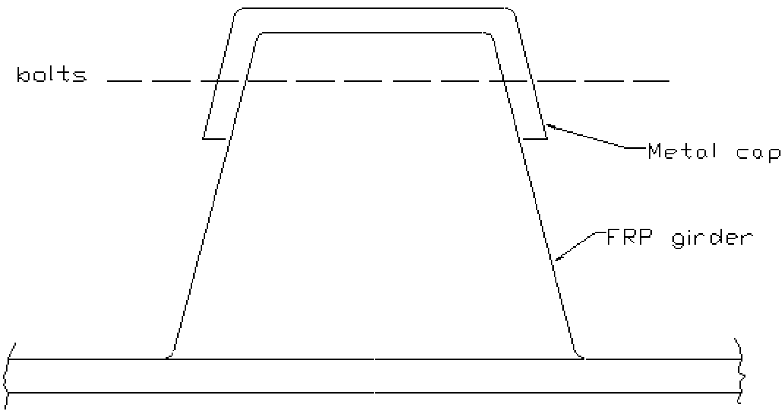
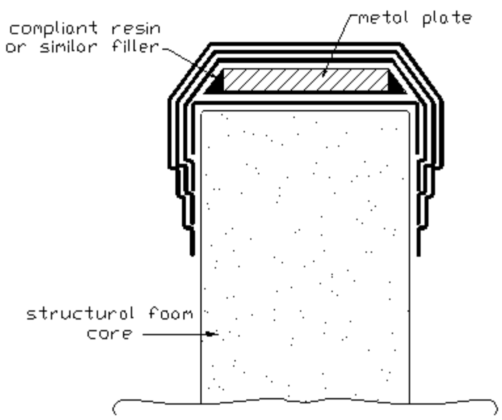


Figure 1.4.11: Engine Foundation



1.5 Mechanical Connections

1.5.1 Generally, components may be fastened with bolts, machine screws, or self-tapping screws. Where machine screws or self-tapping screws are used, they are not to have countersunk heads. Shanks of all threaded fastenings are to be long enough to pass through the joints. Where watertight joints are required, suitable sealants or bedding compounds are to be used in addition to the fastenings. Mechanical fastenings are to be of material suitable for the service intended and are to be either galvanically compatible with the materials being fastened or provided with the necessary insulation. Brass fastenings are not to be used. Non corrosion resistant fastenings are to be galvanized. Fastenings used with aluminum alloys are to be austenitic corrosion-resistant (stainless) steel or suitable aluminum alloy. Sizes and specifications are to be indicated on the submitted plans. The diameter of a fastening is not to be less than the thickness of the thinner component being fastened, with a minimum diameter of 6 mm.

1.5.2 Bolts or machine screws are to be used where accessibility permits. The diameter of each fastener is to be at least equal to the thickness of the thinner component being fastened. Bolts and machine screws less than 6,5 mm in diameter are not to be used. Where d is the fastener diameter, fastener centers are to be spaced at a minimum of 3d apart and are to be set in from edges of laminates a minimum of 3d.

1.5.3 Generally, in fiber reinforced plastic construction, all bolted connections are to be made through solid fiber reinforces plastic inserts. Where this is not possible, all low-density core material is to be replaced with a structurally effective insert. Diameters of fastening holes arc not to exceed fastening diameters by more than 0,4 mm.

1.5.4 Washers or backing plates are to be installed under all fastening heads and nuts that otherwise would bear on laminates. Washers are to measure not less than 2,25d in outside diameter and 0,1d in thickness. Nuts are to be either of the self-locking type, or other effective means are to be provided to prevent backing off. Care is to be taken to ensure that the nut or other component into which the bolt is screwed is of materials having the same mechanical properties. Where materials of different strength arc used, this is to be considered in determining the length of thread engagement between members.

1.5.5 Bolted connections are, in general, to be bonded along all mating surfaces using an accepted structural adhesive, applied in accordance with the manufacturer's requirements. Boltholes are to be drilled, without undue pressure at breakthrough, having a diametric tolerance of two percent of the bolt diameter. Where bolted connections are to be made watertight, the hole is to be sealed with resin and allowed to cure before the bolt is inserted. In areas of high stress or where unusual bolting configurations, on the basis of equivalence with the above requirements, are proposed, testing may be required.

1.5.6 In general, no self-tapping screws are to be used in fiber reinforced plastic construction. Self-tapping screws having straight shanks may be used for non-structural connections, where lack of accessibility prohibits the use of through fastenings. Where used, self-tapping screws are to have coarse threads.

1.5.7 Backing bars and tapping plates. The requirements for backing plates and bars will be individually considered on the basis of the loading imposed, details of which are to be indicated on the submitted plans. Metal plates and bars are to be suitably protected against corrosion. Tapping plates may be encapsulated within the laminate, laminated to or bolted to the structure. Tapping plate edges or corners are to be suitably rounded.

SECTION 2 Deck / Hull and Bulkhead Joints

2.1 Weather joints

The connection is to develop the strength of the deck and shell laminate, whichever is stronger, by either a bolted or bonded connection. Where flanges are used, the hull flanges are to be equal in thickness and strength to the hull laminates and the deck flanges are to be equal in strength and thickness to the deck laminates. Where bolts are used to develop the required strength of the connection, the faying surfaces are to be set in bedding compound, polyester putty, or other approved material. Minimum widths of overlaps and minimum bolt diameters are to be in accordance with Table **2.1.1. Intermediate values may be obtained by interpolation. FRP bonding angles, where used, are to have flanges of the same strength and of at least one half the thickness of single skin hull or deck laminate. On sandwich laminates, they are to have the same strength and thickness as the skin of a sandwich laminate, based on the thicker of the two laminates being connected. The widths of the flanges are to be in accordance with the widths of overlaps in** Table **2.1.1. Typical acceptable arrangements for deck to hull and deck to deckhouse connections are shown in Figure 2.1.1, Figure 2.1.2, Figure 2.1.3, Figure 2.1.4,**

2.1.1 Figure 2.1.5, Figure 2.1.6, Figure 2.1.7 and Figure 2.1.8.

Table 2.1.1: **Minimum width of overlap and bolt diameter**

Length of craft (m)	Minimum width of overlap (mm)	Minimum bolt diameter (mm)
9	63.5	6.50
12	75.0	7.75
15	87.5	9.00
18	100.0	10.25
21	112.5	11.50
24	125.0	12.75
*Intermediate values may be obtained by linear interpolation		

Figure 2.1.1: Hull-Deck joint

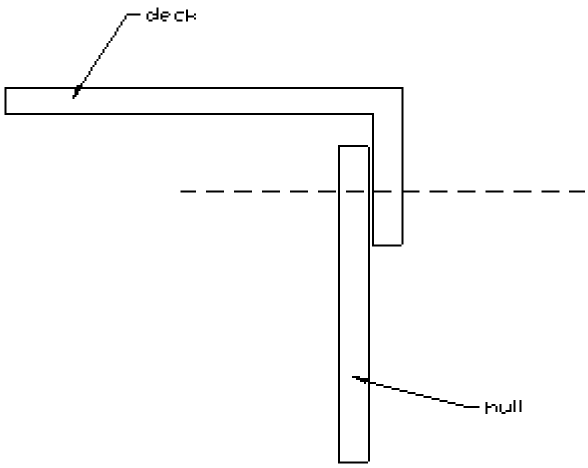


Figure 2.1.2: Hull-Deck joint

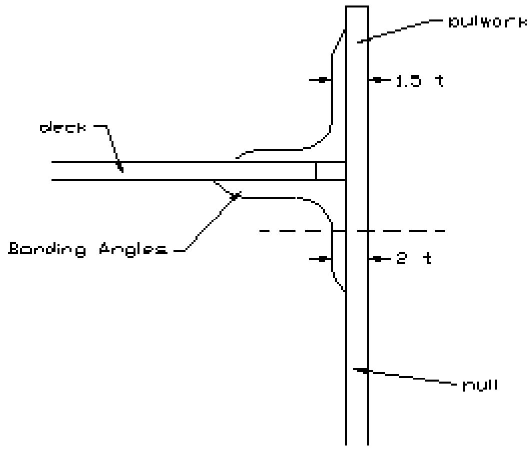


Figure 2.1.3: Hull-Deck joint

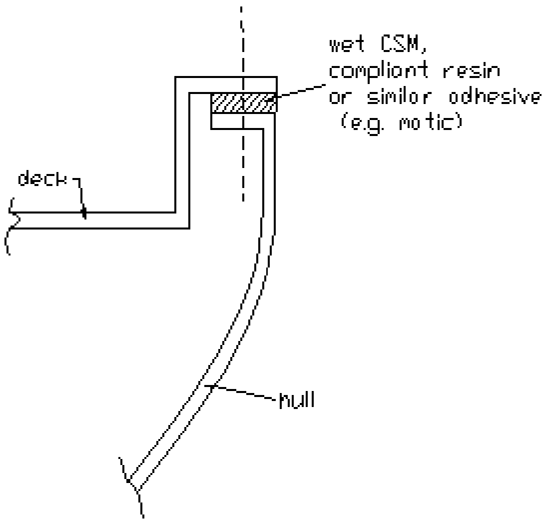


Figure 2.1.4: Hull-Deck joint

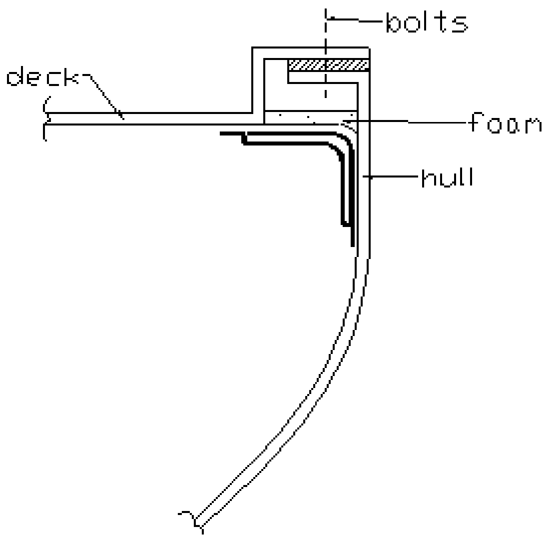


Figure 2.1.5: Hull-Deck joint

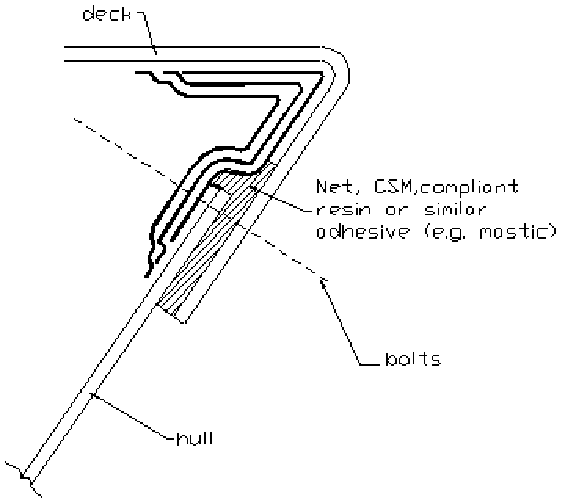


Figure 2.1.6: Hull-Deck joint

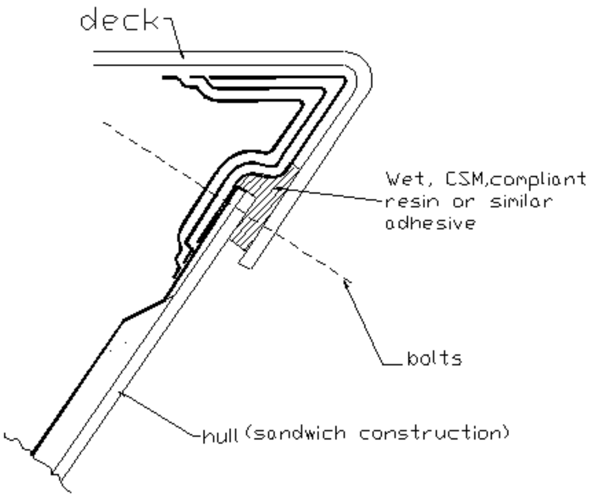


Figure 2.1.7: Deck-Deckhouse joint

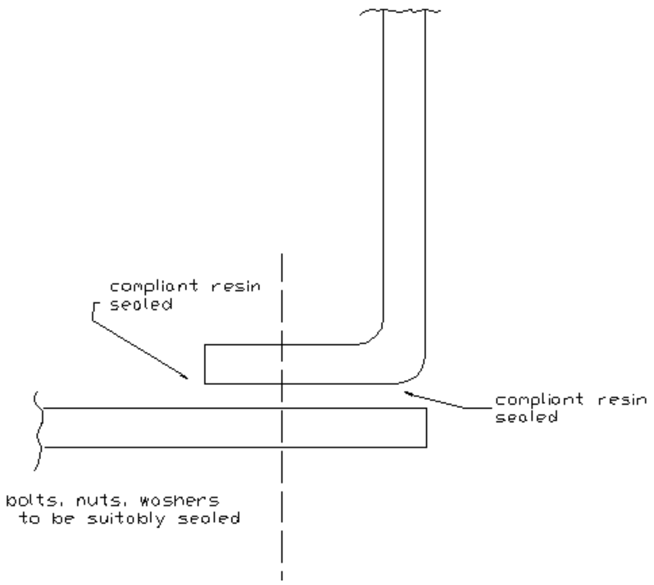
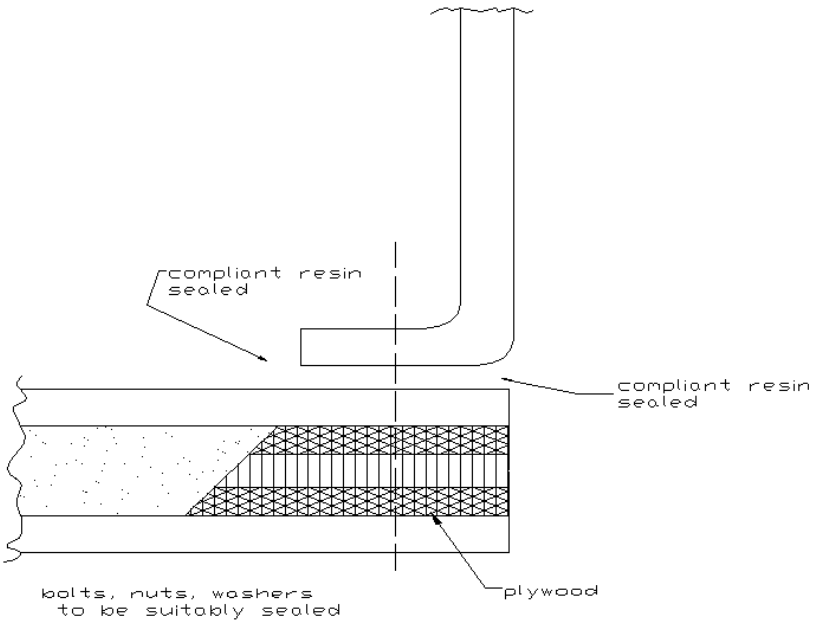


Figure 2.1.8: Deck-Deckhouse joint



2.2 Interior Joints

2.2.1 Interior decks are to be connected to the hull by shelves, stringers or other structural members on both sides by FRP tapes. The connection is to effectively develop the strength of the interior deck. Typical acceptable arrangements for bulkhead to hull or deck connections are shown in Figure 1.3.1, Figure 1.3.2, Figure 1.3.3 and Figure 1.3.4.

SECTION 3 Structural scantlings

3.1 Application

3.1.1 The rules of this section generally apply to monohull planning craft with an overall length not exceeding 36 m and displacement craft up to 60 m in length.

3.1.2 Other types of planning craft like catamarans, hydrofoils, air-cushion vehicles, surface effect ships, wave piercers and small waterplane area twin hulls will be specially considered on a case by case basis.

3.2 Assumptions

3.2.1 The rules of this chapter apply to Fiber Reinforced Plastic hulls built either as a single-skin structure reinforced as necessary by stiffeners, or as a sandwich structure.

3.2.2 The two principal material axes of a laminate or of the skins of a sandwich panel are parallel to the edges of the laminate or the sandwich panel, respectively.

3.2.3 The lateral load acting on the various laminates or sandwich panels is considered to be uniformly distributed.

3.2.4 The laminates or sandwich panels can be either isotropic or orthotropic, without any limit in the difference between the moduli of elasticity in the two principal material axes.

3.3 Notation

3.3.1 The following notation is followed throughout this section:
a= longest side of laminate, in m.
A_s= required stiffener shear area, in cm^2.
B= shortest side of laminate, in m.
E= modulus of elasticity of isotropic laminates or stiffeners, in N/mm^2 (MPa).
E_a= modulus of elasticity in the direction parallel to side a, in N/mm^2 (MPa).
E_b= modulus of elasticity in the direction parallel to side b, in N/mm^2 (MPa).
G= shear modulus of elasticity in the plane of the laminate, in N/mm^2 (MPa).
I= required stiffener moment of inertia, in cm^4.
k_1= section modulus coefficient, given in Table 3.5.1.
k_2= moment of inertia coefficient, given in Table 3.5.1.
k_3= shear area coefficient, given in Table 3.5.1.
k_c= reduction coefficient for plate curvature.
k_{sa}= laminate stress coefficient, given in Figure 3.4.3 and Figure 3.4.5.
k_{sb}= laminate stress coefficient, given in Figure 3.4.3 and Figure 3.4.5.
k_w= laminate deflection coefficient, given in Figure 3.4.2 and Figure 3.4.4.
l= unsupported span of stiffener, in m.
p= design pressure in kN/m^2 (kPa), as given in Chapter 2.
s= stiffener spacing, in m.
SM= required stiffener section modulus, in cm^3.
t= laminate thickness, in mm.
η= non-dimensional generalized rigidity ratio, given in 3.4.4.
v= Poisson's ratio for transverse strain in the direction parallel to side b when stressed in the direction parallel to side a, that is, $v=-\varepsilon_b/\varepsilon_a$.
ρ= non-dimensional affine aspect ratio, given in 3.4.5.
σ= design stress of isotropic laminates or stiffeners, in N/mm^2 (MPa).
σ_a= design stress in the direction parallel to side a, in N/mm^2 (MPa), given in Table 3.4.1.
σ_{au}= ultimate stress in flexure in the direction parallel to side a, in N/mm^2 (MPa).
σ_b= design stress in the direction parallel to side b, in N/mm^2 (MPa), given in Table 3.4.1.
σ_{bu}= ultimate stress in flexure in the direction parallel to side b, in N/mm^2
σ_u= ultimate tensile stress of the stiffener's laminate, in N/mm^2 (MPa).
τ= design shear stress for stiffeners, in N/mm^2 (MPa).
τ_u= ultimate shear stress of the stiffener's web laminate, in N/mm^2 (MPa).

3.3.2 When the material under consideration has different tensile and compressive moduli of elasticity in the two principal material directions, E_a and E_b are proposed to be taken as the mean value of the respective tensile and compressive moduli.

3.4 Single skin construction plating

3.4.1 The required laminate thickness given by the formulae of this sub-section is based on a maximum permissible deflection and a maximum permissible bending stress criterion and is in accordance with local strength requirements.

3.4.2 Bottom shell is considered to extend up to the chine (the upper chine in case of two chines) or to the upper turn of bilge.

3.4.3 The sides of the laminate can be considered as either simply supported or clamped. It is recommended in general that clamped boundary conditions should be considered for the bottom and bulkhead laminates and simply supported boundary conditions for the side, deck, superstructure and deckhouses laminates, provided that laminates have approximately the same dimensions. However, other boundary conditions may be taken into account, based on an acceptable stiffness analysis of the adjacent structure.

3.4.4 The non-dimensional generalized rigidity ratio used in Figure 3.4.1, Figure 3.4.2, Figure 3.4.3 and Figure 3.4.4 is defined as follows:

$$\eta = \frac{\nu \cdot E_b + 2 \cdot G \cdot \left(1 - \nu^2 \cdot \frac{E_b}{E_a}\right)}{\sqrt{E_a . E_b}}$$

For laminates that can be considered isotropic, it is $\eta=1.0$.

3.4.5 The non-dimensional affine aspect ratio used in Figure 3.4.1, Figure 3.4.2, Figure 3.4.3 and Figure 3.4.4 is defined as follows:

$$\rho = \frac{a}{b} \cdot \sqrt[4]{\frac{E_b}{E_a}}$$

For laminates that can be considered isotropic, it is $\rho=a/b$.

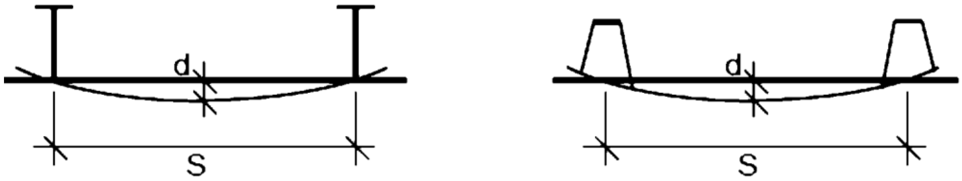
3.4.6 In initial design stages, Poisson’s ratio ν can be taken equal to 0.3. In any case, the values considered both for the Poisson’s ratio and for the ultimate stresses σ_{au} and σ_{bu} are to be verified from the approved test results.

3.4.7 For laminates exhibiting significant curvature, the following reduction coefficient is to be taken into account:

$$k_c = 1 - \frac{d}{S}$$

without being less than 0.75, where distances d and S are defined in Figure 3.4.1 and S is either side a or side b of the laminate, depending on which direction curvature is more significant.

Figure 3.4.1: Definition of curvature reduction coefficient



3.4.8 For simply supported laminates, the required thickness is to be not less than given by any of the following formulae:

$$t = 100 \cdot k_c \cdot \sqrt[3]{\frac{0.6 \cdot k_w \cdot p \cdot b^3 \cdot (E_a - \nu^2 \cdot E_b)}{E_a \cdot E_b}}\ (mm)$$

$$t = 31.623 \cdot k_c \cdot \sqrt{\frac{p \cdot (\alpha^2\ \cdot\ k_{sa} + \nu \cdot b^2 \cdot k_{sb})}{\sigma_\alpha}}\ (mm)$$

$$t = 31.623 \cdot k_c \cdot \sqrt{\frac{p \cdot \left(\nu \cdot a^2 \cdot k_{sa} \cdot \frac{E_b}{E_a} + b^2 \cdot k_{sb}\right)}{\sigma_b}}\ (mm)$$

where coefficients k_w, k_{sa} and k_{sb} are given in Figure 3.4.2 and Figure 3.4.3 as functions of the non-dimensional ratios and and design stresses σ_a and σ_b are given in Table 3.4.1. Coefficient k_c is given in 3.4.7.

3.4.9 For simply supported laminates that can be considered isotropic, the required thickness is to be not less than given by any of the following formulae:

$$t = 100 \cdot k_c \cdot \sqrt[3]{\frac{0.6 \cdot k_W \cdot p \cdot b^3 \cdot (1 - \nu^2)}{E}}, (mm)$$

$$t = 31.623 \cdot k_c \cdot \sqrt{\frac{p \cdot (\nu\ \cdot\ a^2 \cdot k_{sa} + b^2 \cdot k_{sb})}{\sigma}}, (mm)$$

where coefficients k_w, k_{sa} and k_{sb} are given in Figure 3.4.2 and Figure 3.4.3 for η=1.0 and ρ=a/b and design stress σ is given in Table 3.4.1. Coefficient kc is given in 3.4.7.

3.4.10 For clamped laminates, the required thickness is to be not less than given by any of the following formulae:

$$t = 100 \cdot k_c \cdot \sqrt[3]{\frac{0.6 \cdot k_w \cdot p \cdot b^3 \cdot (E_a - \nu^2 \cdot E_b)}{E_a \cdot E_b}}, (mm)$$

$$t = 31.623 \cdot k_c \cdot \sqrt{\frac{p \cdot a^2 \cdot k_{sa}}{\sigma_a}}, (mm)$$

$$t = 31.623 \cdot k_c \cdot \sqrt{\frac{p \cdot b^2 \cdot k_{sb}}{\sigma_b}}, (mm)$$

where coefficients k_w, k_{sa} and k_{sb} are given in Figure 3.4.4 and Figure 3.4.5 as functions of the non-dimensional ratios η and ρ and design stresses σ_a and σ_b are given in Table 3.4.1. Coefficient k_c is given in 3.4.7.

3.4.11 For clamped laminates that can be considered isotropic, the required thickness is to be not less than given by any of the following formulae:

$$t = 100 \cdot k_c \cdot \sqrt[3]{\frac{0.6 \cdot k_w \cdot p \cdot b^3 \cdot (1 - \nu^2)}{E}}, (mm)$$

$$t = 31.623 \cdot k_c \cdot \sqrt{\frac{p \cdot b^2 \cdot k_{sb}}{\sigma}}, (mm)$$

where coefficients k_w, k_{sa} and k_{sb} are given in Figure 3.4.4 and Figure 3.4.5 for η=1.0 and ρ=a/b and design stress σ is given in Table 3.4.1. Coefficient k_c is given in 3.4.7.

Table 3.4.1: Design stresses σ, σ_a and σ_b

Part of the Structure	**σ, σ_a, σ_b**
Bottom shell	$0.333 \cdot \sigma_u$
Side shell	$0.333 \cdot \sigma_u$
Decks	$0.333 \cdot \sigma_u$
Bulkheads	$0.333 \cdot \sigma_u$
Superstructures	$0.333 \cdot \sigma_u$
Deckhouses	$0.333 \cdot \sigma_u$

NOTE:
Ultimate stress σ_u is σ_{au} for design stress σ_a and σ_{bu} for design stress σ_b.

Figure 3.4.2: Simply supported laminates: Deflection coefficient k_w for five values of ratio η, namely 0.2, 0.4, 0.6, 0.8 and 1.0

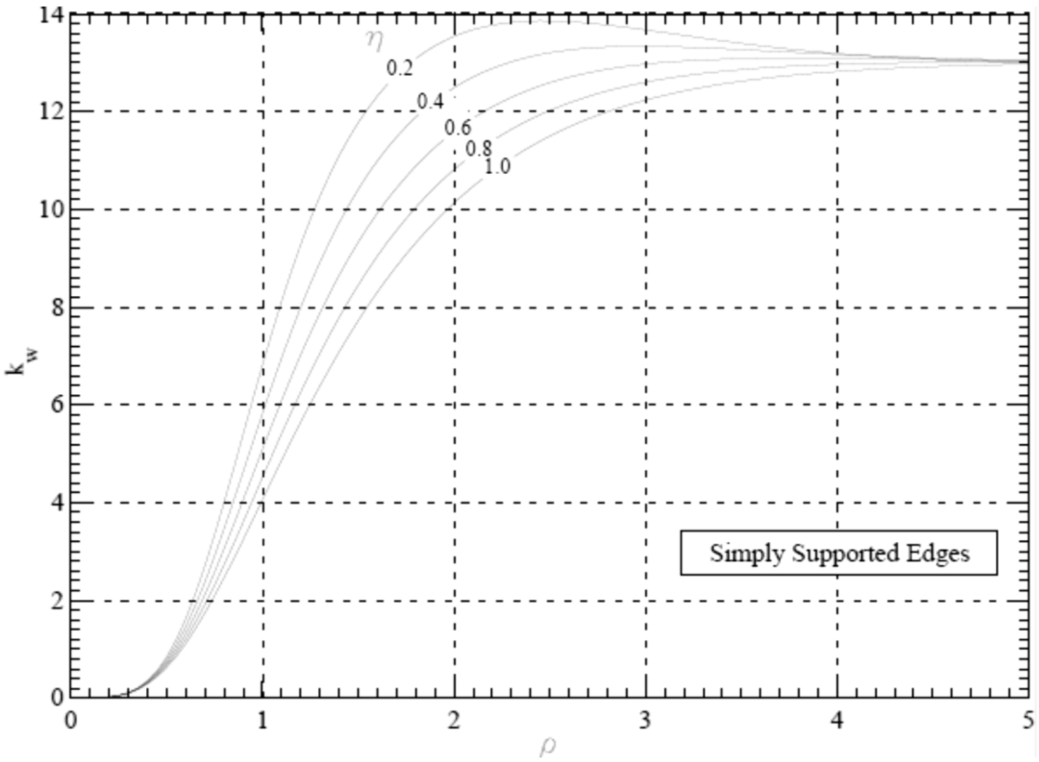


Figure 3.4.3: Simply supported laminates: Stress coefficient k_{sa} and k_{sb} for five values of ratio η, namely 0.2, 0.4, 0.6, 0.8 and 1.0

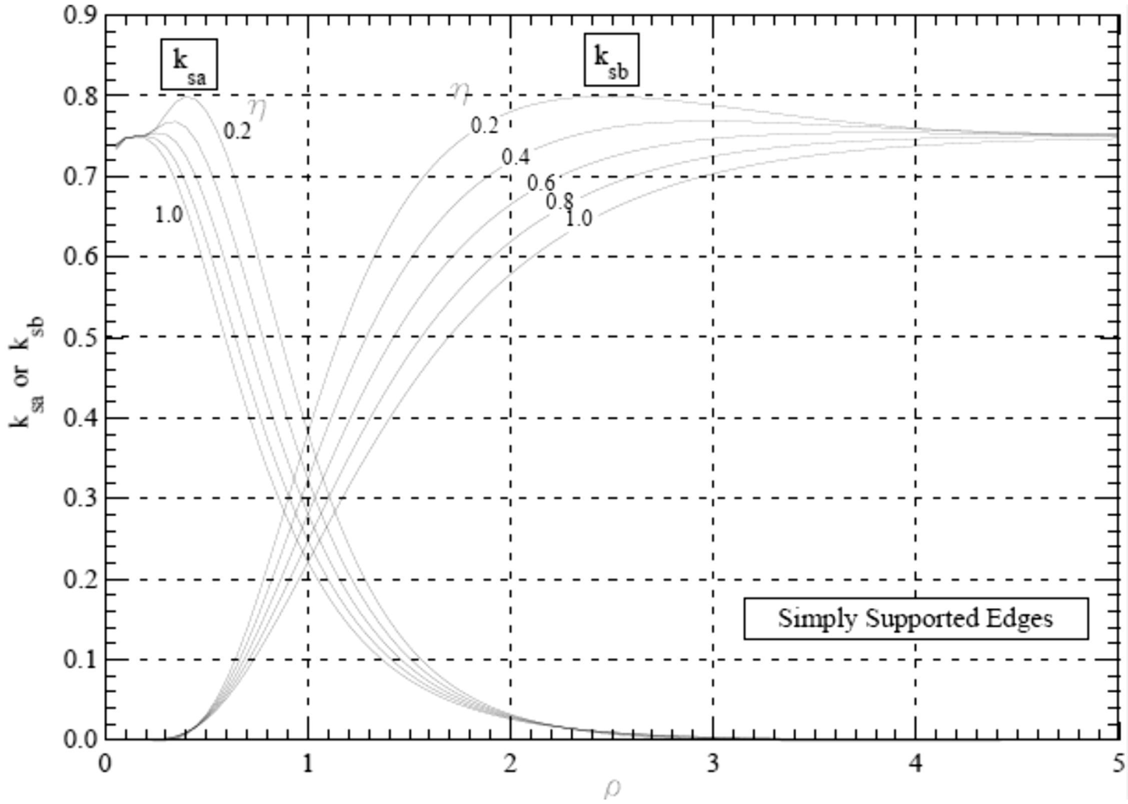


Figure 3.4.4: Clamped laminates: Deflection coefficient k_w for five values of ratio η, namely 0.2, 0.4, 0.6, 0.8 and 1.0

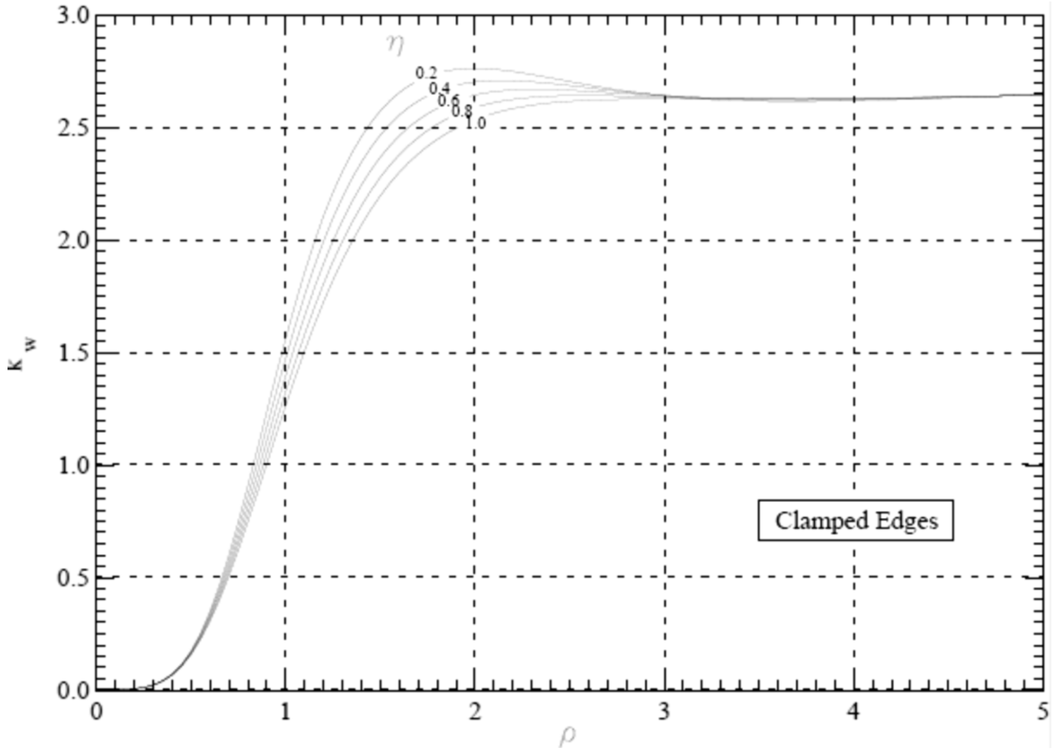
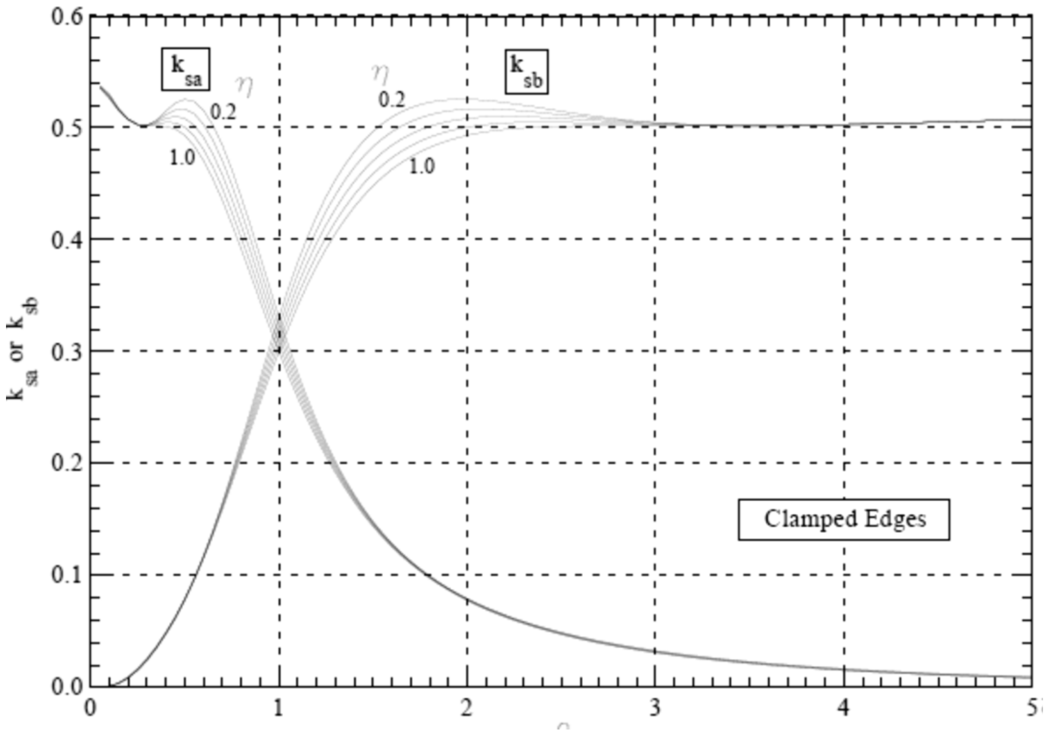


Figure 3.4.5: Clamped laminates: Stress coefficient k_{sa} and k_{sb} for five values of ratio η, namely 0.2, 0.4, 0.6, 0.8 and 1.0



3.5 Stiffeners

3.5.1 The requirements for section modulus, moment of inertia and shear area of this subsection are based on bending of stiffeners by a lateral load, uniformly or linearly distributed over its whole length. Other types of loading is to be specially considered.

3.5.2 In general, plies that form the stiffener profile are layed-up parallel to the direction of the stiffener. They can be either bi-directional with approximately the same stiffness and strength properties in the two principal material in-plane axes, or uni-directional with different stiffness and strength properties in these two material axes.

3.5.3 Laminates that work as bonding means between the plating and the stiffener (bonding angles, flanges, tapes, etc.) are to have comparable stiffness and strength properties with the laminates of the plating and the stiffness they bond.

3.5.4 Great differences between the stiffness and strength properties of the laminates forming the stiffener and those forming the corresponding plating are in general to be avoided.

3.5.5 In case where the stiffener is formed by materials with different moduli of elasticity, this variation should be also taken into account in the section modulus, moment of inertia and shear area calculations.

3.5.6 For stiffeners supporting sandwich panels, only the skin laminate at which the stiffener is attached should be taken into account as effective flange for the section modulus and moment of inertia calculations.

3.5.7 The section modulus of each longitudinal or transverse stiffener, girder and web, including the laminate to which it is attached, is to be not less than given by the following formula:

$$SM = k_1 \cdot \frac{p \cdot s \cdot l^2}{\sigma}, (cm^3)$$

where coefficient k_1 is given in Table 3.5.1 for beams with various boundary conditions and load distributions. In general, the boundary conditions and load distribution for each specific structural member are to be in accordance with Table 3.5.2. Design bending stress σ is not to be taken greater than $0.333 \cdot \sigma_u$.

3.5.8 The moment of inertia of each longitudinal or transverse stiffener, girder and web, including the laminate to which it is attached, is to be not less than given by the following formula:

$$I = k_2 \cdot \frac{p \cdot s \cdot l^3}{E} \cdot 10^3, (cm^4)$$

where coefficient k_2 is given in Table 3.5.1 for beams with various boundary conditions and load distributions. In general, the boundary conditions and load distribution for each specific structural member are to be in accordance with Table 3.5.2. Modulus of elasticity E is to be taken as the equivalent modulus of elasticity of the stiffener cross section, used in the moment of inertia calculations.

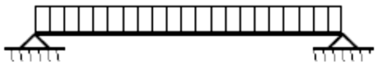
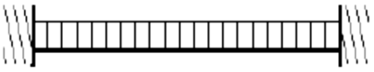
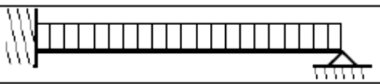
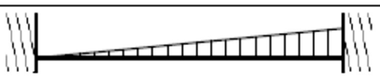
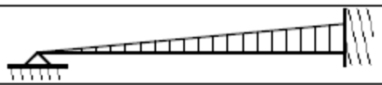
3.5.9 The web area (shear area) of each longitudinal or transverse stiffener, girder and web is to be not less than given by the following formula:

$$A_s = k_3 \cdot \frac{p \cdot s \cdot l}{\tau}, (cm^2)$$

where coefficient k_3 is given in Table 3.5.1 for beams with various boundary conditions and load distributions. In general, the boundary conditions and load distribution for each specific structural member are to be in accordance with Table 3.5.2. Design shear stress τ is not to be taken greater than $0.333 \cdot \tau_u$.

3.5.10 According to general beam theory, coefficients k_1, k_2 and k_3 of paragraphs 3.5.2, 3.5.3 and 3.5.4, respectively, are given in Table 3.5.1, for various boundary conditions and load distributions that are normally met in a ship structure:

Table 3.5.1: Stiffener coefficients k_1, k_2 and k_3

Case	Boundary conditions and load distribution	k_1	k_2	k_3
1		125.0	65.0	7.5
2		83.33	13.0	7.5
3		125.0	27.5	9.4
4		128.3	66.0	10.0
5		100.0	13.1	10.5
6		133.33	24.0	12.0

3.5.11 In general, boundary conditions and load distribution for each specific structural member are to be in accordance with Table 3.5.2, provided that the respective stiffeners are approximately evenly spaced:

Table 3.5.2: Recommended stiffener boundary conditions and load distribution

Structural member		**Boundary Conditions**	**Load distribution**	**Case No.**
	Web frames	CC-SS	Uniform	3
Bottom	Longitudinals between webs	CC-CC	Uniform	2
	Transverse stiffeners	CC-CC	Uniform	2
	Web frames	SS-SS	Triangular	4
Side	Longitudinals between webs	SS-SS	Uniform	1
	Vertical stiffeners	SS-SS	Triangular	4
Deck	All stiffeners	SS-SS	Uniform	1
Superstructure & Deckhouses	All stiffeners	SS-SS	Uniform	1
	Vertical girders	CC-CC	Triangular	5
Bulkheads	Horizontal girders	CC-CC	Uniform	2
	Vertical stiffeners	CC-CC	Triangular	5
	Horizontal stiffeners	CC-CC	Uniform	2

CHAPTER 5 HULL CONSTRUCTION - STEEL

SECTION 1 General

1.1 General Requirements

1.1.1 The Rules apply to mono-hull and multi-hull vessels of normal form, speed and proportions.

1.2 Submitted Documentation

1.2.1 Documentation including the following particulars is to be submitted:

a) Profile and decks
b) Shell expansion
c) Propeller brackets
d) Midship sections showing longitudinal and transverse material
e) Pillars and girders
f) Oiltight and watertight bulkheads
g) Engine room construction
h) Engine and thrust seatings
i) Double bottom construction
j) Aft end construction
k) Hatch cover construction
l) Fore end construction
m) Deckhouses and superstructures
n) Sternframe
o) Equipment
p) Rudder, stock and tiller
q) Loading Manuals, preliminary and final (where applicable)
r) Welding schedule
s) Ice strengthening
t) Scheme of corrosion control (where applicable)
u) Bilge keels showing material grades, welded connections
v) Hull penetration plans
w) Support structure for masts, derrick posts or cranes

1.2.2 The following additional documentation are also to be submitted:

a) Capacity plan
b) Dry-docking plan
c) General arrangement
d) Lines plan or equivalent
e) Sail/rigging plan, indicating loadings (as applicable to sailing craft)
f) Towing and mooring arrangements

1.2.3 The following additional calculations are also to be submitted:
a) Calculation of hull girder still water and dynamic bending moments and shear forces as applicable
b) Calculation of equipment number
c) Freeboard calculation
d) Calculation of hull girder
e) Calculation of local strength (scantling’s check)

1.3 Exceptions

1.3.1 In case of craft which are not covered by the present Rules, such as craft of unsual form, speed or proportions, intended for the carriage of special cargoes, or for special or restricted service, they will be individually considered based on the general requirements of the Rules.

SECTION 2 Design and construction principles

2.1 Continuity and alignment

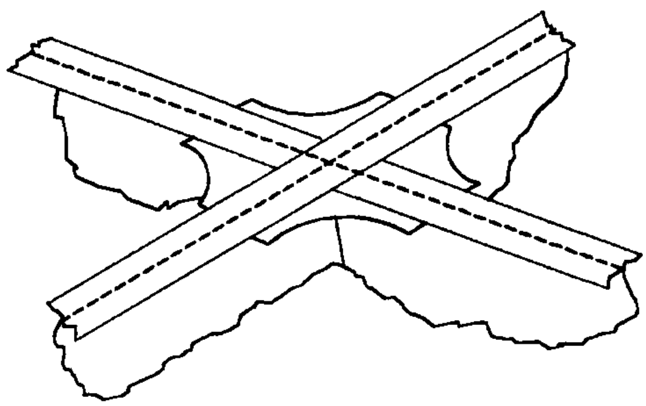
2.1.1 The arrangement of material is to be such as will ensure structural continuity. Abrupt changes of shape or section, sharp corners and points of stress concentration are undesirable and are to be avoided.

2.1.2 Where members abut on both sides of a bulkhead or similar structure, care is to be taken to ensure good alignment.

2.1.3 Pillars and pillar bulkheads are to be fitted in the same vertical line wherever possible, and elsewhere arrangements are to be made to transmit the out of line forces satisfactorily. The load at head and heel of pillars is to be effectively distributed and arrangements are to be made to ensure the adequacy and lateral stability of the supporting members.

2.1.4 Continuity is to be maintained where primary members intersect and where the members are of the same depth, a suitable gusset plate is to be fitted (see Figure 2.1.1).

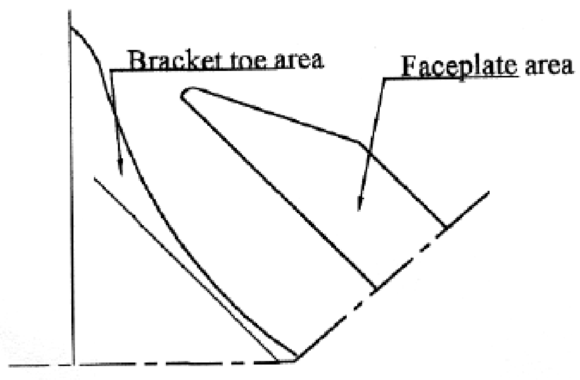
Figure 2.1.1: Primary member intersection



2.1.5 End connections of structural members are to provide adequate end fixity and effective distribution of the load into the supporting structure.

2.1.6 The stress concentrations can be minimised by paying particular attention to the design of the end bracket toes. Sniped face plates which are welded onto the edge of primary member brackets are to be carried well around the radiuses bracket toe and are to incorporate a taper not exceeding one in three. Adequate cross sectional area is to be provided through the bracket toe at the end of the snipe, in case sniped face plates are welded adjacent to the edge of primary member brackets.Generally, this area measured perpendicular to the face plate, is to be not less than 60% of the full cross-sectional area of the face plate (see Figure 2.1.2).

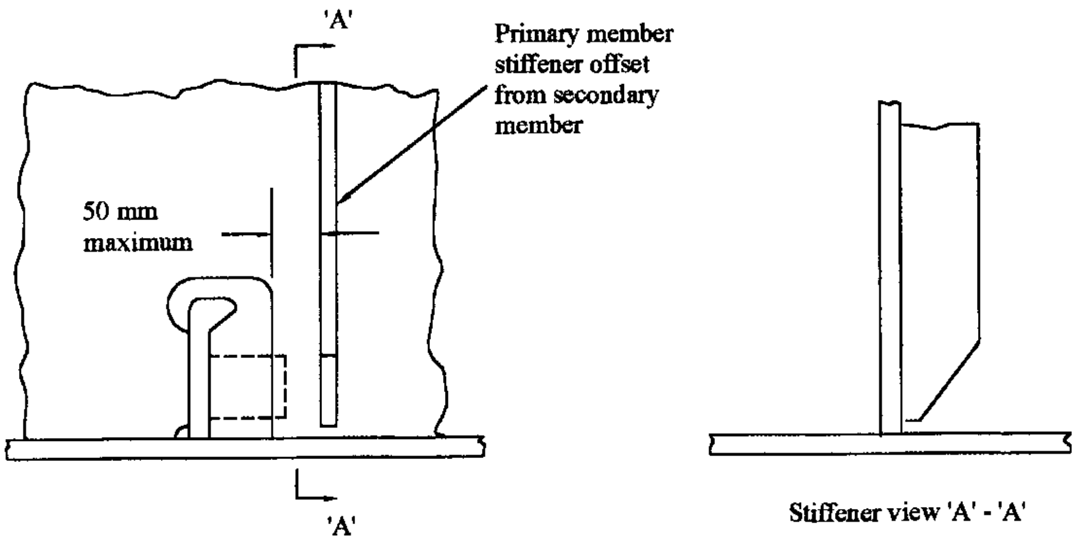
Figure 2.1.2: Bracket toe construction



2.2 Arrangement with offset stiffener

2.2.1 Where the stiffeners of the double bottom floors and transverse bulkheads are unconnected to the secondary members and offset from them (see Figure 2.2.1) the collar arrangement for the secondary members are to satisfy the requirements of 2.3. Moreover, the fillet welds attaching the lugs to the secondary members are to be based on a weld factor of 0,44 for the throat thickness. To facilitate access for welding the offset stiffeners are to be located 50 mm from the slot edge furthest from the web of the secondary member. The ends of the offset stiffeners are to be suitably tapered and softened.

Figure 2.2.1: Arrangement with offset stiffener



2.3 Arrangements at intersection of continuous secondary and primary members

2.3.1 In order to minimise stress concentrations around the perimeter of the opening and in the attached hull envelope or bulkhead plating, cut-outs for the passage of secondary members through the webs of primary members, and the related collaring arrangements, are to be designed. It is necessary to proceed to an investigation of the critical shear buckling stress of the panel, in which the cut-out is made. In high stress areas, the cut-outs for longitudinals are to have double lugs.

2.3.2 The cut-outs are to have a breadth as small as practicable, with the top edge suitably radiuses. Cut-outs are to have smooth edges, and the corner radii are to be as large as practicable, with a minimum of 20% of the breadth of the cut-out or 25 mm, whichever is the greater. It is suggested that the web plate connection to the hull envelope, or bulkhead, end in a smooth tapered 'soft toe'. In Figure 9.3.3 of Part 2, Chapter 9 of "Rules and Regulations for the Classification and Construction of Steel Ships" are shown recommended shapes of cut-out. However, consideration will be given to other shapes, in order to maintain equivalent strength and minimize stress concentration.

2.3.3 Symmetrical secondary members are to be connected by lugs on one or both sides, as necessary.

2.3.4 Asymmetrical secondary members are to be connected on the heel side to the primary member web plate. Additional connection by lugs on the opposite side may be required.

2.3.5 Where the primary member stiffener is connected to the secondary member it is to be aligned with the web of the secondary member, except where the face plate of the latter is offset and abutted to the web. In that case the stiffener connection is to be lapped.

2.3.6 Fabricated longitudinals, which may have the face plate welded to the underside of the web, leaving the edge of the web exposed, are not recommended for side shell and longitudinal bulkhead longitudinals. Where it is proposed to fit such sections, a symmetrical arrangement of connection to transverse members is to be incorporated. This can be achieved by fitting backing structure on the opposite side of the transverse web or bulkhead.

2.3.7 Where a bracket is fitted to the primary member web plate in addition to a connected stiffener it is to be arranged on the opposite side to, and in alignment with the stiffener. The arm length of the bracket is to be not less than the depth of the stiffener, and its cross-sectional area through the throat of the bracket is to be included in the calculation of the area of the primary web stiffener in way of the connection.

2.3.8 Alternative arrangements will be considered on the basis of their ability to transmit load with equivalent effectiveness. Testing procedures and details of the calculations made are to be submitted.

2.4 Openings

2.4.1 Manholes, lightening holes and other cut-outs are to be avoided in way of concentrated loads and areas of high shear. In particular, manholes and similar openings are not to be cut in vertical or horizontal diaphragm plates in narrow cofferdams or in floors and double bottom girders close to their span ends, or below the heels of pillars, unless the stresses in the plating and the panel buckling characteristics have been calculated and found satisfactory.

2.4.2 Manholes, lightening holes and other openings are to be suitably framed and stiffened where necessary.

2.4.3 Drain and air holes, scallops and notches are to be kept at least 200 mm clear of the toes of end brackets and other areas of high stress. Openings are to be well rounded with smooth edges. Closely placed scallops are not permitted. Widely spaced air or drain holes may be accepted, only if they have elliptical shape, or equivalent, to minimize stress concentration and are, in general, cut clear of the weld connection.

2.5 Openings in the web

2.5.1 Where openings are cut in the web, the depth of opening is not to exceed 50% of the web depth, and the opening is to be so located that the edges are not less than 25% of the web depth from the face plate. The length of opening is not to exceed the web depth or 60% of the secondary member spacing, whichever is the greater, and the ends of the openings are to be equidistant from the corners of cut-outs for secondary members. Where larger openings are proposed, the arrangements and compensation required will be specially considered. Openings are to have well rounded corners and smooth edges.

2.6 Tank boundary penetrations

2.6.1 Where structural members pass through the boundary of a tank, and leakage into the adjacent space could be hazardous or undesirable, full penetration welding is to be adopted for the members for at least 150 mm on each side of the boundary. Alternatively a small scallop of suitable shape may be cut in the member close to the boundary outside the compartment, and carefully welded all round.

2.7 Web stability

2.7.1 Primary members of asymmetrical section are to be supported by tripping brackets at alternate secondary members. If the section is symmetrical, the tripping brackets may be four spaces apart.

2.7.2 Tripping brackets are in general required to be fitted at the toes of end brackets and in way of heavy or concentrated loads such as the heels of pillars.

2.8 Weldings

2.8.1 All weldings must comply with the requirements specified in the “Rules and Regulations for the Classification and Construction of Steel Ships”, Part 2- Chapter 9, Chapter 10, Chapter 11.

SECTION 3 Structural Scantlings for Mono-Hull Vessels – General Principles and Requirements

3.1 Application

3.1.1 The requirements of this Chapter are applicable to mono-hull craft of steel construction.

3.2 Direct calculations

3.2.1 In case the design, form or proportions of the craft are unusual, or the speed of the craft exceeds 60 knots, the scantlings are to be determined by direct calculation.

3.2.2 In any case direct calculations based on well-established principles of mechanics may be used alternatively or complementary to these Rules, provided that the achieved level of safety remains equivalent.

3.3 Symbols and definitions

3.3.1 The following symbols are used in this chapter:

L= Rule length of craft, in meters, is the distance on the summer load waterline from the forward side of the stem to the after side of the rudder post or to the center of the rudder stock if there is no rudder post. L is to be not less than 96%, and need not be greater than 97%, of the extreme length on the summer load waterline. In craft without rudders, the Rule length, L, is to be taken as 97% of the extreme length on the summer load waterline

B= moulded breadth of craft, in meters,

I= moment of inertia, in cm^4

SM= section modulus of the stiffening member, in cm^3

A= shear area of stiffener web, in cm^2

p= design pressure, in kN/m^2

s= stiffener spacing, in mm

l= stiffener overall length, in meters

l_e= effective span length, in meters

K_{AR}= panel aspect ratio correction factor as defined in 3.9

t_p= plating thickness, in mm

K_c= convex curvature correction factor as defined in 3.8

σ_s= guaranteed minimum yield strength of the material, in N/mm^2

$\tau_s = \sigma_s/\sqrt{3}$

k_1= high tensile steel factor

$= 235/\sigma_s$

$k_2 = 635/(\sigma_s+\sigma_u)$

σ_u= specified minimum ultimate tensile strength of the material, N/mm^2

E= modulus of elasticity, in N/mm^2

3.4 Material properties

3.4.1 The basic grade of steel used in the determination of the Rule scantling requirements is taken as mild steel with the following mechanical properties:

Table 3.4.1: Mechanical properties

Yield strength (minimum)	235 N/mm^2
Tensile strength	400-490 N/mm^2
Modulus of elasticity	200 × 10^3 N/mm^2

3.5 Higher tensile steels

3.5.1 Steels having a yield stress not less than 265 N/mm² are regarded as higher tensile steels (HTS).

3.5.2 Where higher tensile steels are to be used, due allowance is given in the determination of the Rule requirement for plating thickness and stiffener section modulus, inertia and cross-sectional area by use of the following correction factors:

a) Plating thickness factor = $\sqrt{k_1}$

b) Section modulus and cross sectional area factor = k_1 where k_1 is as defined in 3.3.1.

3.5.3 The minimum moment of inertia of higher tensile steel stiffening members is to be not less than that required for mild steel stiffening members.

3.6 Corrosion

3.6.1 All steelwork, except inside integral fuel tanks, is to be suitably protected against corrosion. This may be by coating or, where applicable, by a system of cathodic protection.

3.6.2 Steelwork is to be suitably cleaned and cleared of millscale before the application of any coating. It is recommended that blast cleaning, or other equally effective means, be employed for this purpose.

3.6.3 Where an impressed current cathodic protection system is fitted, plans showing the proposed layout of anodes, reference cells, wiring diagram and the means of bonding-in of the rudder and propeller are to be submitted.

3.6.4 The minimum thickness of plating given in this chapter is based on the assumption that there is negligible loss in strength by corrosion. Where this is not the case the minimum thickness will be specially considered.

3.7 Effective width of attached plating

3.7.1 In case of primary support members the effective width of the attached plating may be taken equal to one-half of the sum of the spacings between parallel adjacent members or equivalent support.

3.7.2 In case of secondary stiffening members the effective width of the attached plating may be taken as:

$$2 \cdot t_p \cdot \sqrt{\frac{E}{\sigma_s}}\ mm,$$

but not greater than the actual spacing of the stiffeners. In the above formula σ_s is not to be taken greater than 235 N/mm^2 for mild steel or 340 N/mm^2 for higher tensile steel.

3.7.3 Where the web of the stiffener intersects the actual plating at an angle less than 70^o the properties of the section are to be determined about an axis parallel to the attached plating.

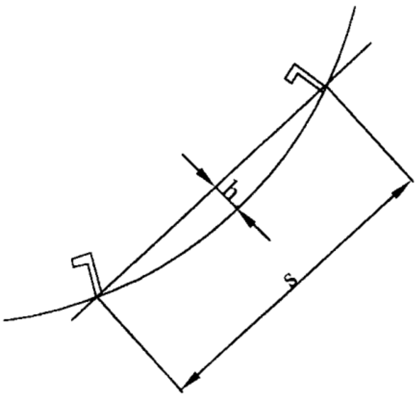
3.8 Consideration of convex curvature

3.8.1 For panels exhibiting significant curvature, the following reduction coefficient is to be taken into account:

$$K_c = 1 - \frac{h}{s}$$

without being less than 0,75, where distances h and s are defined in Figure 3.8.1.

Figure 3.8.1: Convex curvature



3.9 Aspect ratio correction

3.9.1 The thickness of plating as determined by the Rules may be reduced when the panel aspect ratio is taken into consideration. In such cases a panel aspect ratio correction factor may be applied:

$$K_{AR} = A_R \cdot (1 - 0,25 \cdot A_R) \text{ for } A_R \leq 2$$
$$K_{AR} = 1 \text{ for } A_R > 2$$

where:

K_{AR}= aspect ratio correction factor
A_R= panel aspect ratio
= panel length/panel breadth

3.10 General plating thickness

3.10.1 The thickness of plating, t, is, in general to be in accordance with the following formula:

$$t = 0{,}0225 \cdot s \cdot K_c \cdot K_{AR} \cdot \sqrt{\frac{p}{\sigma}}, \qquad mm$$

where:

σ= limiting bending stress value for the plating element under consideration given in Table 3.11.1

s, K_c, K_{AR}, p, σ_a = as defined in 3.3.1.

3.11 Stiffening general

3.11.1 The requirements for section modulus, inertia and web area stiffening members are in general to be in accordance with the following:

a) Section modulus:

$$SM = C_{SM} \cdot \frac{p \cdot s \cdot {l_e}^2}{\sigma} \; cm^3$$

where:

C_{SM} = section modulus coefficient dependent on the loading model assumption taken from Table 3.14.2

σ= limiting bending stress value for stiffening member given in Table 3.11.1

p, s, l_e and σ_s= as defined in 3.3.1.

b) Inertia:

$$I = C_I \cdot f_\delta \frac{p \cdot s \cdot {l_e}^3}{E} \cdot 10^4, cm^4$$

where:

C_I= inertia coefficient dependent on the loading model assumption taken from Table 3.14.2,

f_δ= limiting deflection value for stiffener member given in Table 3.11.2,

p, s, l_e and E= as defined in 3.3.1.

c) Web area:

$$A = C_A \cdot \frac{p \cdot s \cdot l_e}{100 \cdot \tau} \; cm^2$$

where:

C_A= web area coefficient dependent on the loading model assumption taken from Table 3.14.2,

τ= limiting shear stress value for stiffener member given in Table 3.11.1,

p, s, l_e and τ_s= as defined in 3.3.1.

Table 3.11.1: Limiting stress coefficients for local loading (to be continued)

Item	Limiting stress value		
	Bending stress σ	**Shear stress τ**	**Equivalent stress**
Shell envelope			
Bottom shell plating - slamming zone	$0{,}85\cdot\sigma_s$	-	-
- elsewhere	$0{,}75\cdot\sigma_s$	-	-
Side shell plating - slamming zone	$0{,}85\cdot\sigma_s$	-	-
- elsewhere	$0{,}75\cdot\sigma_s$	-	-
Keel	$0{,}75\cdot\sigma_s$	-	-
Bottom structure			
Secondary stiffening - slamming zone	$0{,}75\cdot\sigma_s$	$0{,}75\cdot\tau_s$	
- elsewhere	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	
Primary girders and web frames	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	$0{,}75\cdot\sigma_s$
Engine girders	$0{,}55\cdot\sigma_s$	$0{,}55\cdot\tau_s$	$0{,}75\cdot\sigma_s$
Side structure			
Secondary stiffening - slamming zone	$0{,}75\cdot\sigma_s$	$0{,}75\cdot\tau_s$	
- elsewhere	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	
Primary girders and web frames	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	$0{,}75\cdot\sigma_s$
Bow doors			
Plating	$0{,}65\cdot\sigma_s$		
Secondary stiffening	$0{,}51\cdot\sigma_s$	$0{,}433\cdot\tau_s$	
Primary stiffening	$0{,}51\cdot\sigma_s$	$0{,}34\cdot\tau_s$	$0{,}64\cdot\sigma_s$
Main / strength deck plating and stiffeners			
Plating	$0{,}75\cdot\sigma_s$		
Secondary stiffening	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	
Primary girders and web frame	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	$0{,}75\cdot\sigma_s$
Hatch covers	$0{,}55\cdot\sigma_s$	$0{,}55\cdot\tau_s$	$0{,}64\cdot\sigma_s$
Superstructures / deckhouses			
Deckhouse front 1st tier - plating	$0{,}65\cdot\sigma_s$	-	-
- stiffening	$0{,}60\cdot\sigma_s$	$0{,}60\cdot\tau_s$	-
Deckhouse front upper tiers - plating	$0{,}75\cdot\sigma_s$		
- stiffening	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	-
Deckhouse aft and sides - plating	$0{,}75\cdot\sigma_s$		
- stiffening	$0{,}75\cdot\sigma_s$	$0{,}75\cdot\tau_s$	-
Coachroof - plating	$0{,}65\cdot\sigma_s$		
- stiffening	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	-
House top - plating	$0{,}75\cdot\sigma_s$		
- stiffening	$0{,}75\cdot\sigma_s$	$0{,}75\cdot\tau_s$	-
Lower/inner decks and house top subject to personnel loading	$0{,}75\cdot\sigma_s$		
- plating	$0{,}60\cdot\sigma_s$	$0{,}60\cdot\tau_s$	-
- stiffening			-
Bulkheads			
(a) Collision bulkhead - plating	$0{,}75\cdot\sigma_s$	-	-
- secondary stiffening	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	-
- primary stiffening	$0{,}65\cdot\sigma_s$	$0{,}65\cdot\tau_s$	$0{,}75\cdot\sigma_s$

(b) Watertight bulkhead - plating - secondary stiffening - primary stiffening	$1,00 \cdot \sigma_s$ $0,95 \cdot \sigma_s$ $0,90 \cdot \sigma_s$	- $0,95 \cdot \tau_s$ $0,90 \cdot \tau_s$	- - $1,00 \cdot \sigma_s$
Watertight bulkhead doors	$0,825 \cdot \sigma_s$	$0,825 \cdot \tau_s$	-
Structure supporting watertight doors	$0,80 \cdot \sigma_s$	$0,80 \cdot \tau_s$	-
(c) Minor bulkheads - plating - secondary stiffening - primary stiffening	$0,65 \cdot \sigma_s$ $0,65 \cdot \sigma_s$ $0,65 \cdot \sigma_s$	- $0,65 \cdot \tau_s$ $0,65 \cdot \tau_s$	- - $0,75 \cdot \sigma_s$
(d) Deep tank bulkheads - plating	$0,65 \cdot \sigma_s$	-	-
- secondary stiffening	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	-
- primary stiffening	$0,75 \cdot \sigma_s$	$0,75 \cdot \tau_s$	-

Table 3.11.2: Limiting deflection ratio

Item		Deflection ratio, f_δ
Bottom structure		
	- secondary stiffening	8,00
	- primary girders and web frames	10,00
Side structure		
	- secondary stiffening	8,00
	- primary girders and web frames	10,00
Main/strength deck structures		
	- secondary stiffening	10,00
	- primary girders and web frames	12,50
	- hatch covers	12,50
Superstructures/deckhouses stiffeners		
Generally - secondary		6,00
	- primary	7,50
Coachroof - secondary		8,00
	- primary	10,00

Item		Deflection ratio, f_δ
House top	- secondary	6,00
	- primary	6,00
Lower/inner decks and house top subject to personnel loading		
	- secondary members	8,00
	- primary members	10,00
Deep tank structures		
Stiffeners	- secondary members	10,00
	- primary members	12,50
Watertight bulkhead structures		
Stiffeners	- secondary members	6,00
	- primary members	7,50

3.12 Geometric properties and proportions of stiffener sections

3.12.1 In order to avoid structural instability and appearance of local buckling, the proportions of stiffening members are in general to be in accordance with the requirements of paragraphs 3.12.2 , 3.12.3, 3.12.4, 3.12.5 and 3.12.6.

3.12.2 In case of flat bars the minimum web thickness should be greater than 1/15 of the web depth and always greater than 3 mm.

3.12.3 Where rolled or built sections are used the minimum web thickness should be at least equal to 1/50 of the web depth and always greater than 3 mm. In this case the width of the unsupported face plate or flanges should not be greater than 16 times the thickness of the face plate or flange.

3.12.4 The dimensions of a flat bar stiffener must comply with the following requirement:

$$\frac{h_w}{t_w} \leq 20 \cdot \sqrt{k}$$

Where:

h_w= flat bar height, in mm.

t_w= flat bar thickness, in mm.

k= see Part 3, Chapter 3, Paragraph 3.1.1

3.12.5 The dimensions of a T-section stiffener are to comply with the following requirements:

$$\frac{h_w}{t_w} \leq 55 \cdot \sqrt{k}$$

$$\frac{b_f}{t_f} \leq 33 \cdot \sqrt{k}$$

$$b_f\ t_f \geq \frac{h_w\ t_w}{6}$$

Where:

h_w= web height, in mm.

t_w= web thickness, in mm.

b_f = flange width, in mm.

t_f = flange thickness, in mm.

k= see Part 3, Chapter 3, Paragraph 3.1.1

3.12.6 The dimensions of an angle stiffener are to comply with the following requirements:

$$\frac{h_w}{t_w} \leq 55 \cdot \sqrt{k}$$

$$\frac{b_f}{t_f} \leq 16{,}50 \cdot \sqrt{k}$$

$$b_f\ t_f \geq \frac{h_w\ t_w}{6}$$

Where:

h_w= web height minus the flange thickness, in mm.

t_w= web thickness, in mm.

b_f = flange width minus the web thickness, in mm.

t_f = flange thickness, in mm.

k= see Part 3, Chapter 3, Paragraph 3.1.1

3.13 Effective span length

3.13.1 The effective length of span of a stiffening member depends on length of the member and the design of each end connections. In general, the effective length of span is always equal or less than the physical length of the member.

3.13.2 The effective length of span of primary supporting members is the distance between the two span points, which should be taken at a distance b_e from each end of the member, where b_e is defined as follows:

$$b_e = b_d \left(1 - \frac{d_w}{d_b}\right)$$

where:

b_e, b_b, d_w and d_b = as shown in Figure 3.14.1.

3.13.3 The effective length of span of rolled or built up secondary stiffening members is the distance between the two span points, which in this case should be taken at the point where the depth of the end bracket, measured from the face of the secondary stiffening member, is equal to the depth of the member, see Figure 3.14.1. Where there is no end bracket, the span point is to be measured between primary member webs.

3.13.4 Where the stiffening member is curved then the span is to be taken as the effective chord length between span points.

3.14 End brackets

3.14.1 Where a longitudinal strength member is cut at a primary support and the continuity of strength is provided by brackets, the scantlings of the end brackets are to be such that their section modulus and effective cross-sectional area are not less than those of the member.

3.14.2 In other cases the scantlings of the bracket are to be based on the modulus, according to the Table 3.14.1.

Figure 3.14.1: Span points

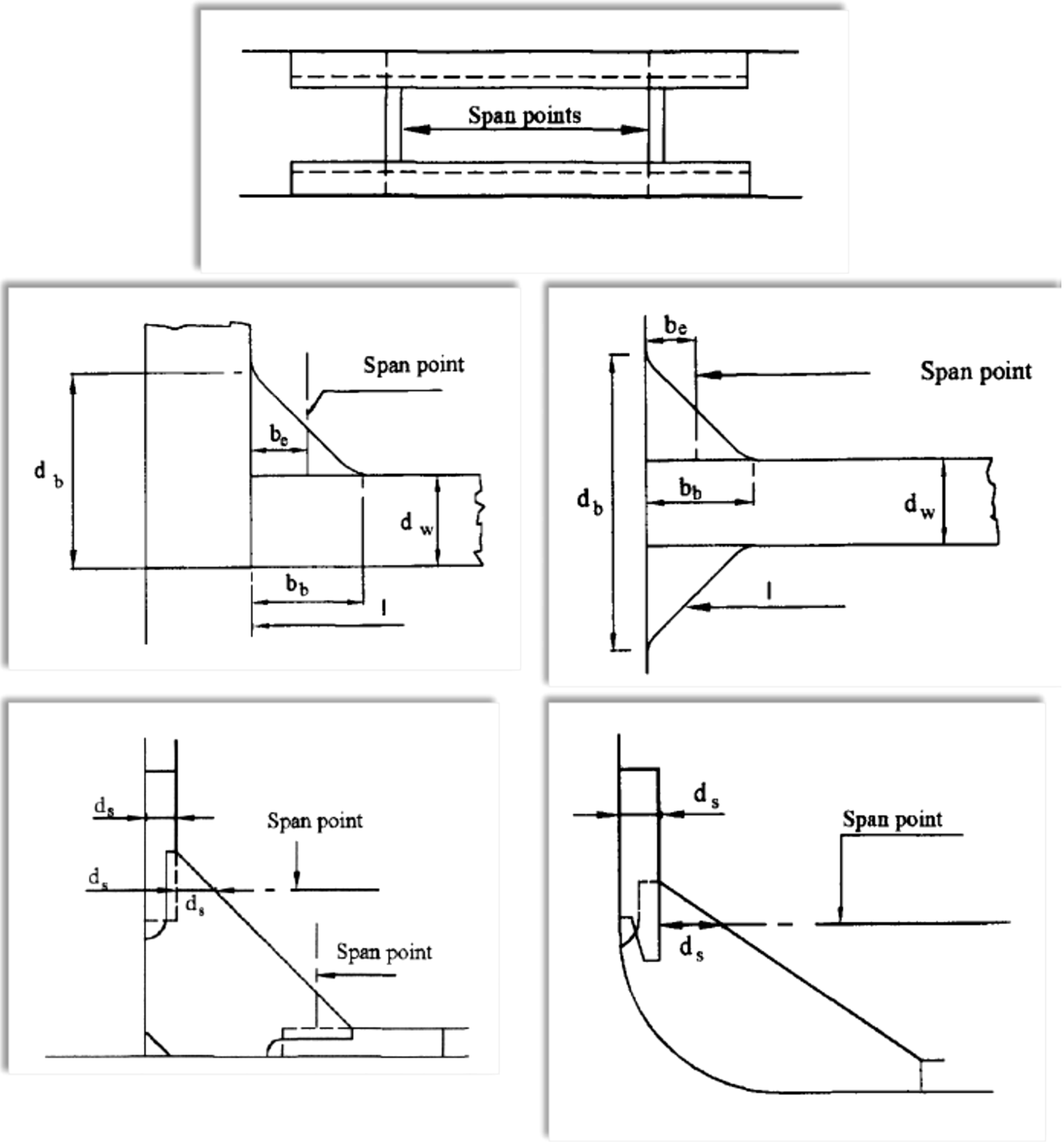
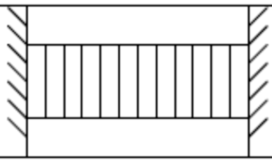
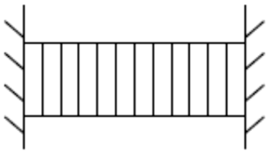
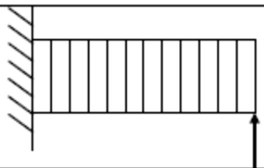
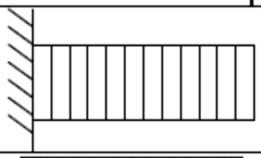
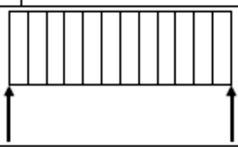


Table 3.14.1: Section modulus of brackets

Location of the bracket	Section Modulus of the bracket
Bracket at the head of a main transverse frame where frame terminates	modulus of the frame
Bracket connecting stiffener to primary member	modulus of the stiffener
Brackets connecting lower deck beams or longitudinals to the main frame in the forward 0,5L	modulus of the frame
Elsewhere	the lesser modulus of the members being connected by the bracket

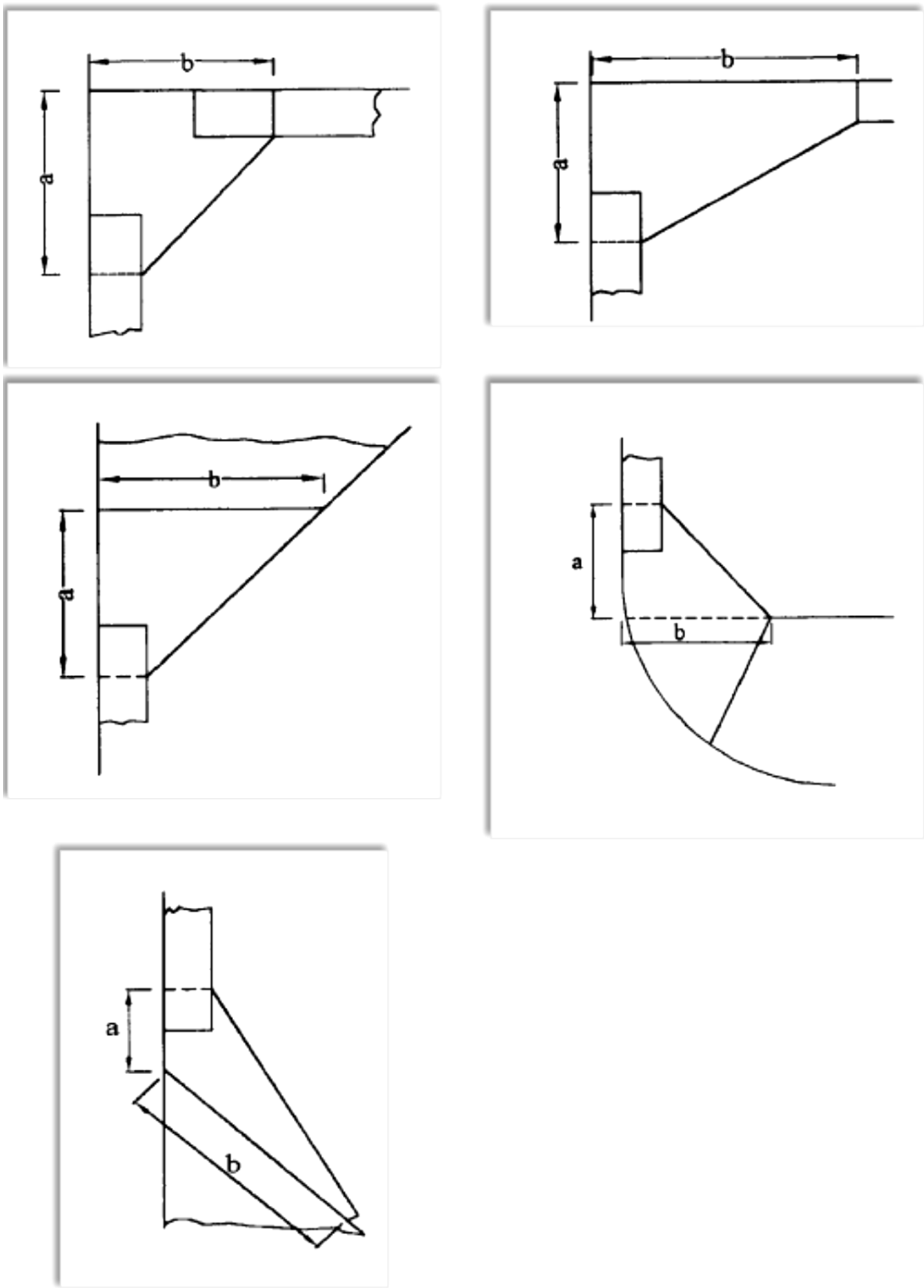
Table 3.14.2: Section modulus, inertia and web area coefficients

Load Model	Position 1 2 3	Position	Web area coefficient C_A	Section modulus coefficient C_{SM}	Inertia coefficient C_I	Application
(a)		1 2 3	1/2 - 1/2	1/12 1/24 1/12	- 1/384 -	Primary and other members where the end fixity is considered encastre
(b)		1 2 3	1/2 - 1/2	1/10 1/10 1/10	- 1/288 -	Local, secondary and other members where the end fixity is considered to be partial
(c)		1 2 3	5/8 - 3/8	1/8 9/128 -	- 1/185 -	Various
(d)		1 2 3	1 - -	1/2 - -	- - 1/8	Various
(e)		1 2 3	1/2 - 1/2	- 1/8 -	- 5/384 -	Hatch covers,glazing and other members where the ends are simply supported

3.14.3 The web thickness and face flat area of end brackets are not in general to be less than those of the connecting stiffeners. In addition to this, the stiffener proportion requirements of **Error! Reference source not found.** are to be satisfied.

3.14.4 In Figure 3.14.2 are shown diagrammatically typical arrangements of stiffener end brackets.

Figure 3.14.2: Stiffener end brackets



3.14.5 The lengths, a and b of the arms are measured from the plating to the toe of the bracket and are to be such that:

$$\alpha \geq 0{,}8 \cdot l_b$$
$$b \geq 0{,}8 \cdot l_b$$
$$\alpha + b \geq 2{,}0 \cdot l_b$$

where a and b are the actual lengths of the two arms of the bracket, in mm, measured from the plating to the toe of the bracket.

$$l_b = 90 \cdot \left(2 \cdot \sqrt{\frac{SM}{\left(14 + \sqrt{SM}\right)}} - 1\right) mm$$

where:

SM= the section modulus of the secondary member, in cm³

l_b should not be taken as less than twice the web depth of the stiffener on which the bracket scantlings are to be based.

3.14.6 Where any of the following apply, the free edge of the bracket is to be stiffened:
a) The bracket is fitted at the lower end of main transverse side framing.
b) The section modulus, SM, exceeds 500 cm³.
c) The length of free edge exceeds 40 times the bracket thickness.

3.14.7 Where a face flat is fitted, its breadth, b_f, is to be not less than:

$$b_f = 40 \cdot \left(1 + \frac{SM}{1000}\right) mm$$

but not less than 50 mm.

3.14.8 Where the stiffening member is lapped onto the bracket, the length of overlap is not to be less than $10\sqrt{SM}$, or the depth of stiffener, whichever is the greater.

3.14.9 Where the edge is stiffened by a welded face flat, the cross-sectional area of the face flat is to be not less than:

a) $0{,}009 \cdot k_1 \cdot b_f \cdot T_B$ cm² for offset edge stiffening.

b) $0{,}014 \cdot k_1 \cdot b_f \cdot T_B$ cm² for symmetrically placed stiffening.

where:

T_B= the thickness of the bracket, in mm

b_f= breadth of face flat, in mm

k_1= as defined in 3.3.1

3.14.10 Where the free edge of the bracket is hollowed out, it is to be stiffened or increased in size to ensure that the modulus of the bracket through the throat is not less than that of the required straight edged bracket.

3.14.11 The arrangement of the correction between the stiffener and the bracket is to be such that at no point in the connection is the actual modulus reduced to less than that of the stiffener with associated plating.

3.15 Primary member end connections

3.15.1 The scantling requirements for primary member end connections in dry spaces and in tanks of all craft types are generally to comply with the requirements of 3.14, taking SM as the section modulus of the primary member.

3.15.2 Primary members must have adequate lateral stability and web stiffening. Furthermore, the structure is to be arranged in such a way to minimise hard spots and other sources of stress concentration. The openings are to have smooth edges and well rounded corners and are to be located having regard to the stress distribution and buckling strength of the panel.

3.15.3 Primary members are to be arranged in such a way to ensure effective continuity of strength, and abrupt changes of depth or section are to be avoided. Where members abut on both sides of a bulkhead, or on other members, arrangements are to be made to ensure that they are in alignment. Primary members in tanks are to form a continuous line of support and wherever possible, a complete ring system.

3.15.4 Primary members are to be provided with adequate end fixity by end brackets or equivalent structure. The design of end connections and their supporting structure is to be such as to provide adequate resistance to rotation and displacement of the joint and effective distribution of the load from the member.

3.15.5 Where primary members are subject to concentrated loads, particularly if these are out of line with the member web, additional strengthening may be required.

3.15.6 Where the primary member is supported by structure which provides only a low degree of restraint against rotation, the member is generally to be extended beyond the point of support and thereafter tapered and/or scarfed into the adjacent structure over a distance generally not less than two frame spaces.

3.15.7 The thickness of the bracket is to be not less than that of the primary member web. The free edge of the bracket is to be stiffened.

3.15.8 Where a member is continued over a point of support, such as a pillar or pillar bulkhead stiffener, the design of the end connection is to be such as to ensure the effective distribution of the load into the support.

3.15.9 Where a deck girder or transverse is connected to a vertical member on the shell or bulkhead, the scantlings of the latter may be required to be increased to provide adequate stiffness to resist rotation of the joint.

3.15.10 Connections between primary members forming a ring system are to minimise stress concentrations at the junctions. Integral brackets are generally to be radiuses or well rounded at their toes. The arm length of the bracket, measured from the face of the member, is to be not less than the depth of the smaller member forming the connection.

3.16 Secondary member end connections

3.16.1 Secondary members, such as, beams, longitudinals, frames and bulkhead stiffeners forming part of the hull structure, are to be effectively continuous and are to be suitably bracketed at their end connections.

SECTION 4 Single bottom structure

4.1 Single bottom structure and appendages

4.1.1 The following requirements apply to ships with single bottom construction in association with transverse and longitudinal framing systems.

4.2 Keel

4.2.1 The breadth, and thickness of plate keels are to comply with the requirements of 6.2.

4.2.2 The cross-sectional area, A, and thickness, t, of bar keels are not, in general, be taken as less than:

$$A = k_1 \cdot (L+1) \ cm^2$$

$$t = \sqrt{k_1} \cdot (0{,}5 \cdot L + 6) \ mm$$

where:

L, k_1= as defined in 3.3.1.

4.3 Centre keelson

4.3.1 A centre keelson is to be fitted throughout the length of the hull in association with transverse frames, transverses supporting longitudinals or where the breadth of floors at the upper edge is greater than 1,5 m.

4.3.2 Centre keelsons are to be formed of intercostal or continuous plate webs with a face plate welded to the upper edge. The face plate should be continuous. Where girder webs are intercostal, additional bracketing and local reinforcement will be required to maintain the continuity of structural strength.

4.3.3 The web depth of the centre keelson is, in general, to be equal to the depth of the floors at the centreline as specified in 4.5.3.

4.3.4 The web thickness t is to be taken not less than the greater of the following values:

$$t = \sqrt{k_1} \cdot \left(\sqrt{L} + 1\right) \ mm \ or$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14} L + 1}\right) \ mm \ or$$

$$4{,}0 \ mm$$

where:

L, k_1, k_2 = as defined in 3.3.1.

4.3.5 The cross sectional area of the face plate of the centre girder A, is to be not less than:

$$A = 0{,}3 \cdot L \cdot k_1 \ cm^2$$

4.3.6 The face flat area of the centre girder outside 0,5·L amidships may be 80% of the value given in 4.3.5.

4.3.7 The thickness of the face plate is not to be less than the thickness of the web.

4.3.8 The ratio of the width to thickness of the face plate is to be not less than eight but should not exceed sixteen.

4.3.9 Additionally, the requirements of 7.3 for bottom longitudinal primary stiffeners are to be complied with.

4.4 Side girders

4.4.1 Where the floor breadth at the upper edge exceeds 6,0 m, side girders are to be fitted at each side of the centre girder such that the spacing between the side and centre girders or between the side girders themselves is not greater than 3 metres. Side girders where fitted are to extend as far forward and aft as practicable and are, in general, to terminate in way of bulkheads, deep floors or other primary transverse structure.

4.4.2 The web thickness of side girders is to be taken as not less than the greater of the following values:

$$t = \sqrt{k_1 \cdot L} \ mm$$

$$t = \sqrt{k_2} \cdot \left(2 \cdot \sqrt{\frac{1}{11} L} + 0{,}8\right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_1, k_2=as defined in 3.3.1

4.4.3 The cross sectional area of the face plate and the thickness of side girders are to comply with the requirements for plate floors as defined in 4.5.6 and 4.5.7.

4.4.4 Watertight side girders, and side girders forming the boundaries of tank spaces, are also to comply with the requirements for watertight bulkheads and deeptanks as detailed in 9.3 and 9.5.

4.5 Floors general

4.5.1 In transversely framed craft, plate floors are generally to be fitted at each frame and underneath every bulkhead.

4.5.2 In longitudinally framed craft, plate floors are to be fitted at every transverse web frame and bulkhead and generally at a spacing not exceeding 2 m. Additional transverse floors or webs are in general to be fitted at half web-frame spacing in way of engine seatings and thrust bearings, pillars, skegs, ballast /bilge keels and the bottom of the craft forward.

4.5.3 The overall depth, d_f, of plate floors at the centreline is not to be taken as less than:

$$d = 40 \cdot B + 35 \cdot D \ mm, \quad when\ B < 10\ m,$$

$$d = 65 \cdot B + 35 \cdot D - 200\ mm, \quad when\ B \geq 10\ m,$$

where:

D= the depth.

4.5.4 The web thickness, t, of plate floors, is to be in accordance with **Error! Reference source not found.** and is to be taken as not less than the greater of the following values:

$$t = \sqrt{k_1} \cdot (0{,}0034 \cdot d + 2{,}25) \cdot (0{,}001 \cdot s + 0{,}5)\ mm$$

$$t = \sqrt{k_2} \cdot \left(2 \cdot \sqrt{\frac{1}{11} L} + 0{,}8\right)\ mm\ or$$

$$3{,}5\ mm$$

where:

d= to be determined from 4.5.3,
k_1, k_2, s= as defined in 3.3.1

4.5.5 If the side frames of the craft are attached to the floors by brackets, the depth of floor may be reduced by 15% and the floor thickness determined using the reduced depth. PHRS may accept alternatives to requirements given in 4.5.3, provided they are deemed to be equivalent. The brackets are to be flanged and have the same thickness as the floors, and their arm lengths clear of the frame are to be the same as the reduced floor depth given above.

4.5.6 The cross sectional area of the face plate, A, is not to be taken as less than:

$$A = 0{,}15 \cdot L \cdot k_1\ cm^2$$

where:

k_1, L= as defined in 3.3.1

4.5.7 The thickness of the face plate is to be not less than the thickness of the web and the ratio of the width to the thickness of the face flat is to be not less than eight but is not to exceed sixteen.

4.5.8 Additionally the requirements of 7.6 for bottom transverse web frames are to be complied with.

4.5.9 Floors are generally to be continuous from side to side.

4.5.10 The floors in the aft peak are to extend over and provide effective support to the stern tube(s) where applicable.

4.5.11 Watertight floors, or floors forming boundaries of tank spaces, are also to comply with the requirements for watertight bulkheads or deeptanks as detailed in 9.3 and 9.5.

4.6 Floors in machinery spaces

4.6.1 The thickness, t, of the floors in machinery spaces is to be 1mm greater than that required by 4.5.4.

4.6.2 The depth and section modulus of floors anywhere between engine or gearbox girders is to be not less than that required to maintain continuity of structural integrity or 50% of the depth given in 4.5.3.

4.7 Rudder horns

4.7.1 The scantlings of the rudder horn are to be such that the section modulus against transverse bending at any horizontal section XX (see Figure 4.7.1) is not less than:

$$SM = 1{,}5 \cdot k_1 \cdot R_A \cdot K_v \cdot (V+3)^2 \cdot \sqrt{(a^2 + 0{,}5 \cdot b^2)} \quad cm^3$$

where:

R_A= total rudder area, in m²

V= maximum speed in the fully loaded condition, in knots

K_v= 1,0 for displacement craft with $\frac{V}{\sqrt{L_{WL}}} < 3$

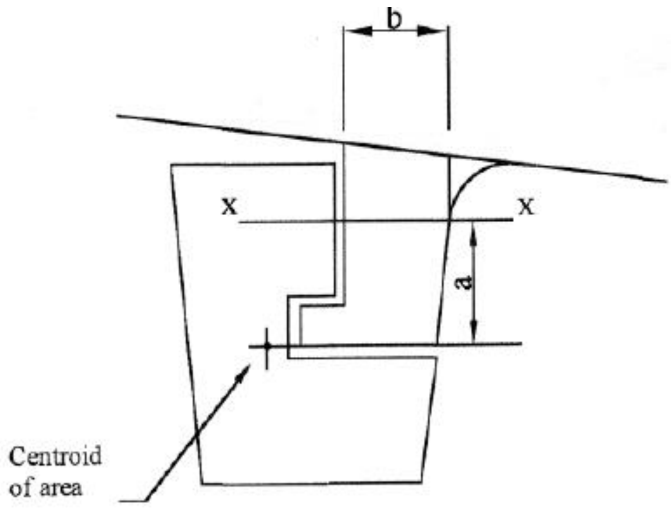
= $(1{,}12 - 0{,}005 \cdot V)^3$ for planing and semi-planing craft with $\frac{V}{\sqrt{L_{WL}}} \geq 3$

a, b= dimensions, in meters, as given in Figure 4.7.1.

L_{WL}= waterline length

4.7.2 The shell plating thickness in way of the rudder horn does not need to be taken as greater than the keel thickness required by 6.2.

Figure 4.7.1: Rudder horn



4.7.3 See also Part 3 Chapter 9 for more details concerning the rudder horn.

4.8 Skeg construction

4.8.1 Skegs are to be effectively integrated into the adjacent structure and their design is to be such as to facilitate this.

4.9 Forefoot and stem

4.9.1 The thickness of plate stems at the waterline is to comply with the requirements for plate keels as given in 6.2.

4.9.2 The cross-sectional area of bar stems, A, is not to be taken as less than:

$$A = 0{,}8 \cdot L \cdot k_1 \ cm^2$$

where:

L, k_1= as defined in 3.3.1.

SECTION 5 Double bottom structure

5.1 General

5.1.1 The following requirements provide for double bottom construction of steel mono-hull craft in association with either transverse or longitudinal framing.

5.1.2 The double bottom is to be made as wide as possible.

5.1.3 The double bottom is to be fitted extending from the collision bulkhead to the aft peak bulkhead.

5.1.4 If the double bottom is not continuous from the aft peak bulkhead to the collision bulkhead, the margin plate, side girders and centre girder must be connected to the longitudinal structure of the single bottom or shall scarf two frame spaces into the single bottom structure.

5.1.5 If the depth of the double bottom does not remain constant, efficient means of transmission of loads within 0,6L amidships are to be provided.

5.2 Keel

5.2.1 The scantlings of bar and plate keels are to comply with the requirements of 4.3.

5.2.2 Duct keels, where arranged, are to have a side plate thickness not less than:

$$t = \sqrt{k_1} \cdot (0{,}008 \cdot d_{DB} + 1) \ mm$$

but need not be taken as greater than 90% of the centre girder thickness given in 5.3,

where:

d_{DB}= the Rule centre girder depth given in 5.3.3

k_1= as defined in 3.3.1.

5.2.3 Where a duct keel forms the boundary of a tank, the requirements of 9.4 and 9.5 for deep tanks are to be complied with.

5.2.4 The duct keel width is in general to be 15% of the beam or 2 metres, whichever is the lesser, but in no case is it to be taken as less than 630 mm.

5.3 Centre girder

5.3.1 A centre girder is to be fitted throughout the length of the craft. The web thickness, t, is not to be less than that the maximum value required by:

$$t = \sqrt{k_1} \cdot (0{,}1 \ \cdot L + 3) \ mm$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14} L + 1}\right) \ mm \ or$$

$$4{,}0 \ mm$$

-Outside 0,4 · L amidships

$$t = \sqrt{k_1} \cdot (0{,}1 \cdot L + 2)\ mm$$

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{2} L} + 1 \right)\ mm\ or$$

$$4{,}0\ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

5.3.2 The geometric properties of the girder section are to be in accordance with **Error! Reference source not found.**.

5.3.3 The overall depth of the centre girder, d_{DB}, is to be taken as not less than 630 mm and is to be sufficient to give adequate access to all parts of the double bottom.

5.3.4 Additionally, the requirements of 7.3 for bottom longitudinal primary stiffeners are to be complied with.

5.4 Side girders

5.4.1 Where the floor breadth does not exceed 6,0 m, side girders are not required. Vertical stiffeners are to be fitted to the floors on each side, the number and positions of these stiffeners being dependent on the arrangement of the double bottom structure.

5.4.2 Where the breadth of floor is greater than 6,0 m, additional side girders having the same thickness as the floors are to be fitted. The number of side girders is to be such that the distance between the side girders and centre girder and margin plate, or between the side girders themselves, does not exceed 3,0 metres. The web thickness of the side girders is to be taken as not less than the maximum value obtained by:

$$t = \sqrt{k_2} \cdot \left(2 \cdot \sqrt{\frac{1}{11} L} + 0{,}8 \right)\ mm\ or$$

$$3{,}5\ mm$$

where:

L, k_2= as defined in 3.3.1.

5.4.3 Side girders, where fitted, are to extend as far forward and aft as practicable and are in general to terminate in way of bulkheads, deep floors or other primary transverse structure.

5.4.4 Where additional side girders are fitted in way of main machinery seatings, they are to be integrated into the structure of the craft and extended forward and aft as far as practicable.

5.4.5 Under the main engine, girders extending from the bottom shell to the top plate of the engine seating are to be fitted. The height of the giders is to be not less than the height of the floor. Engine holding-down bolts are to be arranged as near as practicable to the girders and floors. Where this cannot be achieved, bracket floors and/or hanging brackets are to be fitted.

5.4.6 Additionally, the requirements of 7.3 for bottom longitudinal primary stiffeners are to be complied with.

5.5 Plate floors

5.5.1 The web thickness of non-watertight plate floors, t, is to be not less than the maximum value obtained by:

$$t = \sqrt{k_1} \cdot (0{,}05 \cdot L + 3{,}5) \ mm$$

$$t = \sqrt{k_2} \cdot \left(2 \cdot \sqrt{\frac{1}{11} L} + 0{,}8\right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

5.5.2 Additionally, the requirements of 7.6 for bottom transverse web frames stiffeners are to be complied with.

5.5.3 Plate floors are, in general, to be continuous between the centre girder and the margin plate.

5.5.4 In longitudinally framed craft, plate floors or equivalent structure are in general to be fitted in the following positions:

a) At every half frame in way of the main engines, thrust bearings, and bottom of the craft forward.
b) Outboard of the engine seatings, at every frame within the engine room.
c) Underneath pillars and bulkheads.
d) Outside of the engine room at a spacing not exceeding 2,0 m.

5.5.5 Vertical flat bar stiffeners are to be fitted to all plate floors at each longitudinal. Each stiffener is to have a depth of not less than $10 \cdot t$ and a thickness of not less than t, where t is thickness of the plate floor as calculated in 5.5.1.

5.5.6 In transversely framed craft, plate floors are to be fitted at every frame in the engine room, under bulkheads, in way of change in depth of double bottom and elsewhere at a spacing not exceeding 2,0 m.

5.6 Bracket floors

5.6.1 Between plate floors, the shell and inner bottom plating is to be supported by bracket floors. The brackets are to have the same thickness as plate floors and are to be stiffened on the unsupported edge.

5.6.2 In longitudinally framed craft, the brackets are to extend from the centre girder and margin plate to the adjacent longitudinal, but in no case is the breadth of the bracket to be taken as not less than 75% of the depth of the centre girder. They are to be fitted at every web frame at the margin plate, and those at the centre girder are to be spaced not more than 1,0 m apart.

5.6.3 In transversely framed craft, the breadth of the brackets, attaching the bottom and inner bottom frames to the centre girder and margin plate, is to be not less than 75% of the depth of the centre girder.

5.7 Additional requirements for watertight floors

5.7.1 The scantlings of watertight floors are to comply with the requirements for plate floors as given in 5.5.

5.8 Tankside brackets

5.8.1 The scantlings of tankside brackets are to comply with the requirements for plate floors given in 5.5.

5.9 Inner bottom plating

5.9.1 The thickness of the inner bottom plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{4} L} + 1 \right) \; mm \; or$$

$$2{,}5 \; mm$$

where:

L, k_2= as defined in 3.3.1.

5.9.2 Inner bottom plating forming the boundaries of tank spaces is, in addition, to comply with the requirements for watertight bulkheads or deep tanks as detailed in 9.2 or 9.4 respectively. Where the plating forms vehicle, passenger or other decks the requirements of SECTION 8 are to be complied with.

5.9.3 Inner bottom longitudinals are to be supported by inner bottom transverse web frames, floors, bulkheads or other primary structure, generally spaced not more than 2 m apart.

5.9.4 The requirements of section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I, and C_A as detailed in Table 3.14.2 for the load model (a).

5.10 Margin plates

5.10.1 A margin plate, if fitted, is to have a thickness as required for inner bottom plating.

5.11 Manholes

5.11.1 Sufficient manholes are to be cut in the inner bottom, floors and side girders to provide adequate access to, and ventilation of, all parts of the double bottom. The size of the manhole openings is not, in general, to exceed 50% of the double bottom depth unless edge reinforcement is provided.

SECTION 6 Shell envelope plating

6.1 General

6.1.1 The following requirements are applicable to longitudinally and transversely framed shell envelopes.

6.2 Plate keel

6.2.1 The width b and the thickness t of the keel plate are not to be taken as less than the maximum value obtained by:

$$b = 7{,}0 \cdot L + 340 \ mm$$

$$t = 1{,}35 \cdot \sqrt{k_1} \cdot L^{0{,}45} \ mm$$

where:

L, k_1= as defined in 3.3.1.

6.2.2 In no case is the thickness of the keel plate to be less than that of the adjacent bottom shell plating.

6.2.3 The thickness and width of the plate keel are to be maintained throughout the length of the craft from the transom to a point not less than 25% of the freeboard (measured at the forward perpendicular) above the deepest load waterline on the stem. Thereafter the keel thickness may be reduced to that required by 6.3.1 for the stem.

6.2.4 For large or novel craft and for yachts with externally attached ballast keels, the scantlings of the keel will be specially considered.

6.2.5 For bar keels, see 4.2.2.

6.3 Plate stem

6.3.1 The thickness of plate stems, t, is not to be taken as less than:

$$t = \sqrt{k_1} \cdot (0{,}1 \cdot L + 3) \ mm$$

where:

L, k_1= as defined in 3.3.1.

6.3.2 In no case is the thickness of the plate stem to be taken as less than the thickness of the adjacent shell plating.

6.3.3 Plate stems are to be supported by horizontal diaphragms, and where the stem radius is large, a centreline stiffener or web may be required.

6.3.4 For large or novel craft the scantlings of the stem will be specially considered.

6.3.5 The breadth of plate stems is to be not less than the width of keel as required by 6.2.1.

6.4 Bottom shell plating

6.4.1 The thickness of the bottom shell plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{6}L} + 2 \right) \ mm \ or$$

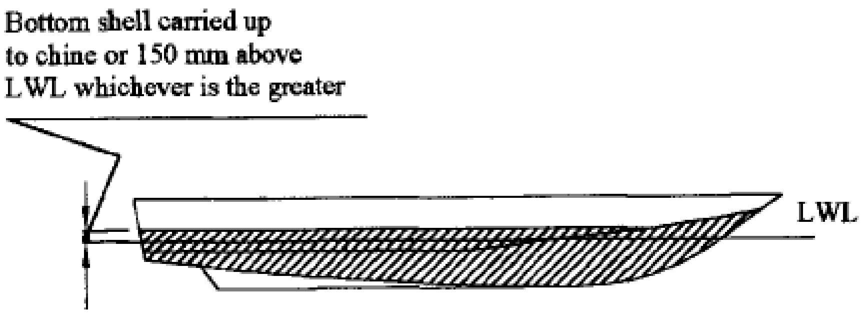
$$3{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

6.4.2 For all craft types the minimum thickness requirement for bottom shell plating is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater see Figure 6.4.1.

Figure 6.4.1: Extent of bottom shell



6.5 Side shell plating

6.5.1 The thickness of the side shell plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{7}L} + 1{,}2 \right) \ mm \ or$$

$$3{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

6.6 Sheerstrake

6.6.1 The sheerstrake is generally to be taken as the side shell, locally reinforced in way of deck/ hull connection and fender attachment. The amount of local reinforcement will be dependent upon the arrangement of structure and the proposed service.

6.6.2 Only the designers/builders are responsible for the fendering arrangements of all craft types. The above mentioned arrangements are outside the scope of classification.

6.6.3 The above mentioned arrangements are outside the scope of classification.

6.6.4 Fishing crafts are in general to have their shell plating scantling as required to satisfy the Rule loadings, increased by 20%. In addition to this, the side shell is not to be taken less than as bottom shell thickness, and where there are gallows, gantries, nets, or lines etc. the plating in way is to be further increased locally and /or suitably protected by sheathing or other means.

6.6.5 Where a rounded sheerstrake is adopted, the radius, in general, is to be not less than 15 times the thickness.

6.6.6 The sheerstrake thickness is to be increased by 20% at the ends of a bridge superstructure extending out to the craft's side. In case of a bridge superstructure exceeding 0,15·L, the side plating at the ends of the superstructure is also to be increased by 25% and tapered gradually into the upper deck sheerstrake.

6.7 Chines

6.7.1 The chine plate thickness is to be equivalent to the bottom shell thickness required to satisfy the Rule pressure loading, increased by 20%, or 6 mm, whichever is the greater.

6.7.2 Where tube is used in chine construction, the minimum wall thickness is to be not less than the thickness of the bottom shell plating increased by 20%.

6.8 Skegs

6.8.1 The thickness of the skeg plating is to be not less than the thickness of the adjacent bottom shell.

6.9 Transom

6.9.1 The thickness of the stern or transom is to be not less than that required for the side or bottom shell as appropriate.

6.10 Shell openings

6.10.1 Sea-inlets, or other openings, are to have well rounded corners and, so far as is practicable, are to be kept clear of the bilge radius, chine or sheerstrake radius.

6.10.2 Openings on or near the bilge radius may be accepted provided that they are of elliptical shape, or equivalent, to minimise stress concentrations and are, in general, to be cut clear of weld connections.

6.11 Sea inlet boxes

6.11.1 The thickness of the sea inlet box plating is to be 2 mm thicker than the adjacent shell plating, or 6 mm, whichever is the greater.

SECTION 7 Shell envelope framing

7.1 General

7.1.1 The following requirements are applicable to longitudinally and transversely framed shell envelopes.

7.2 Bottom longitudinal stiffeners

7.2.1 Bottom longitudinal stiffeners are to be supported by bottom transverse web frames, floors, bulkheads, or other primary structure, generally spaced not more than 2 metres apart.

7.2.2 Bottom longitudinals are to be continuous through the supporting structures.

7.2.3 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (b).

7.3 Bottom longitudinal primary stiffeners

7.3.1 Bottom longitudinal primary stiffeners are to be supported by bottom deep transverse web frames, floors, bulkheads, or other primary structure, generally spaced not more than 6 metres apart.

7.3.2 Bottom longitudinal primary stiffeners are to be continuous through transverse bulkheads and supporting structures.

7.3.3 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.4 Bottom transverse stiffeners

7.4.1 Bottom transverse stiffeners are defined as local stiffening members which support the bottom shell, and which may be continuous or intercostal.

7.4.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (b).

7.5 Bottom transverse frames

7.5.1 Bottom transverse frames are defined as stiffening members which support the bottom shell. They are to be effectively continuous and bracketed at their end connections to side frames and bottom floors as appropriate.

7.5.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.6 Bottom transverse web frames

7.6.1 Bottom transverse web frames are defined as primary stiffening members which support bottom shell longitudinals. They are to be continuous and substantially bracketed at their end connections to side web frames and bottom floors.

7.6.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.7 Side longitudinals stiffeners

7.7.1 The side longitudinals stiffeners are to be supported by side transverse web frames, bulkheads, or other primary structure, generally spaced not more than 2 metres apart.

7.7.2 Side longitudinals are to be continuous through the supporting structures.

7.7.3 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (b).

7.8 Side longitudinal primary stiffeners

7.8.1 Side longitudinal primary stiffeners are to be supported by side transverse web frames, bulkheads, or other primary structure, generally spaced not more than 6 metres apart.

7.8.2 Side longitudinal primary stiffeners are to be continuous through transverse bulkheads and supporting structures.

7.8.3 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.9 Side transverse stiffeners

7.9.1 Side transverse stiffeners are defined as local stiffening members supporting the side shell and may be continuous or intercostal.

7.9.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (b).

7.10 Side transverse frames

7.10.1 Side transverse frames are defined as stiffening members which support the side shell. They are to be effectively continuous and bracketed at their end connections to bottom floors/frames and deck beams as appropriate.

7.10.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.11 Side transverse web frames

7.11.1 Side transverse web frames are defined as primary stiffening members which support side shell longitudinally. They are to be continuous and substantially bracketed at their head and heel connections to deck transverses and bottom web frames respectively.

7.11.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.12 Construction of seatings

7.12.1 Requirements are given in this paragraph for the construction and dimensions of the seatings intended for main machinery and boilers, deck machinery, fishing installations, cargo handling gear, auxiliary machinery, etc.

7.12.2 The construction of seatings shall satisfy the followings requirements:

- The seating shall be of substantial construction to ensure efficient attachment of machinery, gear or device and transmission of forces to the hull framing which shall be sufficiently strong. If necessary, the framing may be strengthened.
- The seating shall be so constructed that the resonance vibration of the seating as a whole and of its structural components can be avoided under all specified running conditions.
- The seating shall be so designed that the plating beneath is accessible for inspection.
- All the vertical plates shall be fitted in line with the main or additional side girders.

7.12.3 The thickness t, in mm, of structural components of a seating of main machinery or boiler shall not be less than the maximum of the following values a and b:

a)

$$t_1 = k_0 \cdot \sqrt[3]{Q} + k_1 \ mm$$

Table 7.12.1: Coefficient k_o

Seating of machinery (boiler)	k_0		
	Top plates	Vertical plates[1]	Brackets, knees
Main internal combustion engine	4,65	3,0	2,5
Main geared turbine set, main diesel generator and propulsion motor	4,15	2,7	2,7
Boiler	3,65	2,4	2,4

[1]In a seating with four vertical plates the thickness of the plates may be taken equal to the thickness of brackets and knees.

Table 7.12.2: Coefficient k_1

Mass of machinery (boiler), in t	⩽20	> 20 ⩽50	> 50 ⩽100	> 100 ⩽200	> 200
k_1	4	3	2	1	0

Where:

Q= mass of machinery or boiler in working condition, in tonnes,

k_0= factor given in Table 7.12.1

k_1= factor given in Table 7.12.2

b)

$$t_2 = k_2 \cdot \sqrt[3]{N} + k_3 \ mm$$

Table 7.12.3: Coefficients k_2 & k_3

N, in kW	Number of vertical plates	Factor	Top plates	Vertical plates	Brackets, knees
⩽1000	2	k_2	1,7	1,1	0,9
		k_3	6	4	3
	4	k_2	1,4	0,9	0,9
		k_3	5	3	3
> 1000	2	k_2	1,0	1,0	0,7
		k_3	13	5	5
	4	k_2	0,8	0,7	0,7
		k_3	11	5	5

Where:

N= specified power of the engine, in kW,

k_2= factor given in Table 7.12.3

k_3= factor given in Table 7.12.3

SECTION 8 Deck structures

8.1 General

8.1.1 The strength deck is:

- The uppermost continuous deck which forms the upper flange of the longitudinal hull girder.
- A superstructure deck which extends up to 0,4L amidships and the length of which exceeds 0,15L. Superstructure decks the length of which is less than 12 m, need not be considered as strength decks.
- A quarter deck or the deck of a superstructure in part below the main deck, which extends through 0,4L amidships.

8.1.2 Deck sectional areas used in the deck area and section modulus calculations are to be maintained throughout the 0,4L amidships. They may be gradually reduced to 50% the normal requirement at 0,15L from the ends.

8.1.3 The geometric properties of stiffener sections are to be in accordance with **Error! Reference source not found.**.

8.2 Strength/Weather deck plating

8.2.1 The thickness of strength/weather deck plating is to be determined from the general plating equation given in 3.10 using the design pressure head from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{7} L} + 1{,}2 \right) \ mm \ or$$

$$3{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

8.2.2 The scantlings of watertight cockpits are to be of equivalent strength to those of the strength/weather deck.

8.3 Lower deck / Inside deckhouse plating

8.3.1 The thickness of the lower deck/inside deckhouse plating is to be determined from the general plating equation given in 3.10 using the design pressure head from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{29} L} + 1{,}7 \right) \ mm \ or$$

$$2{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

8.4 Accommodation deck plating

8.4.1 Accommodation decks are in general to be treated as lower deck/inside deckhouse decks, with their plating requirements determined in accordance with 8.3.

8.5 Cargo deck plating

8.5.1 The thickness of cargo deck plating is to be determined from the general plating equation given in 3.10 using the design pressure head from Part 3, Chapter 2 of the present Rules.

8.6 Strength / Weather deck stiffening

8.6.1 The Rule requirements for section modulus, inertia and web area for the strength/weather deck primary stiffening are to be determined from the general equations given in 3.11, using the design pressure heads from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a). The minimum thickness for the strength/weather deck primary stiffening is to be determined from the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{7} L} + 1{,}2 \right) \; mm \; or$$

$$3{,}0 \; mm$$

where:

L, k_2= as defined in 3.3.1.

8.6.2 The Rule requirements for section modulus, inertia and web area for the strength / weather deck secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

8.7 Lower deck / Inside deckhouse stiffening

8.7.1 The Rule requirements for section modulus, inertia and web area for lower deck / inside deckhouse stiffening are to be determined from the general equations given in 3.11, using the design pressure head from Part 3,Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2. Primary members are assumed to be load model (a) and secondary members load model (b).The minimum thickness for lower deck/inside deckhouse stiffening is to be determined from the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{29} L} + 1{,}7 \right) \; mm \; or$$

$$2{,}0 \; mm$$

8.8 Accommodation deck stiffening

8.8.1 Accommodation decks are in general to be treated as lower deck/inside deckhouse decks, with their scantling requirements determined in accordance with 8.7.

8.9 Cargo deck stiffening

8.9.1 The Rule requirements for section modulus, inertia and web area for cargo deck stiffening are to be determined from the general equations given in 3.11, using the design pressure head from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2. Primary members are assumed to be load model (a) and secondary members load model (b).

8.10 Deck openings

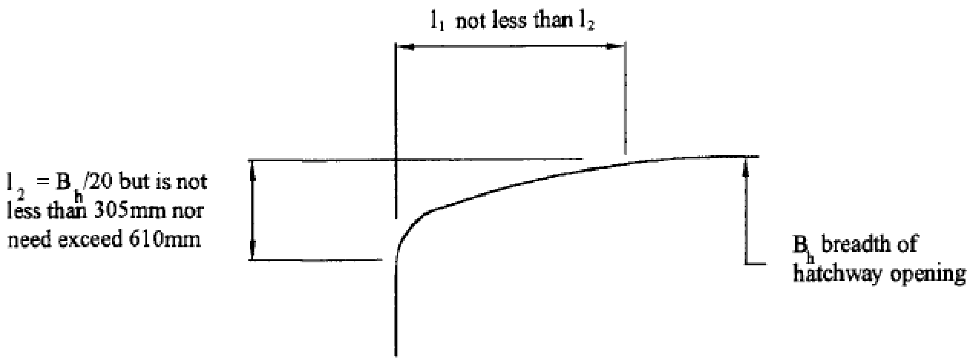
8.10.1 All openings are to be supported by an adequate framing system, pillars or cantilevers. When cantilevers are used scantlings may be derived from direct calculations.

8.10.2 Where stiffening members terminate in way of an opening they are to be attached to carlings, girders, transverses or coaming plates.

8.10.3 The corners of large hatchways in the strength/weather deck within 0,5·L amidships are to be elliptical, parabolic or rounded, with a radius generally not less than 1/24 of the breadth of the opening.

8.10.4 Where elliptical corners are arranged, the major axis is to be fore and aft, the ratio of the major to minor axis is to be not less than two to one nor greater than 2,5 to one, and the minimum half-length of the major axis is to be defined by l_1 in Figure 8.10.1. Where parabolic corners are arranged, the dimensions are also to be shown in Figure 8.10.1.

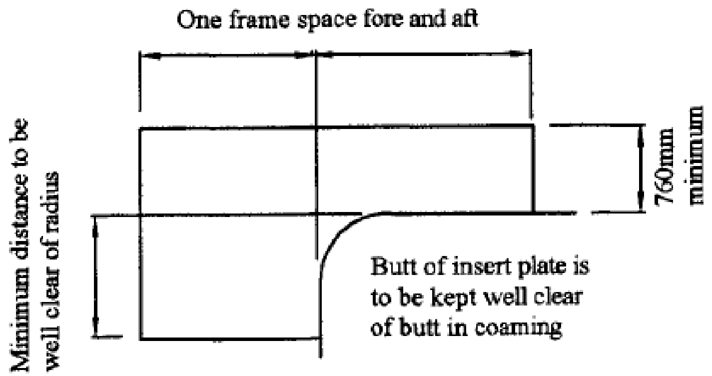
Figure 8.10.1: Hatch opening geometry



8.10.5 Where the corners are parabolic or elliptical, insert plates are not required.

8.10.6 For other shapes of corner, insert plates of the size and extent shown in Figure 8.10.2. will, in general, be required. The required thickness of the insert plate is to be not less than 25% greater than the adjacent deck thickness, outside line of openings.

Figure 8.10.2: Inserts in way of hatch opening



8.10.7 For lower decks the corners of large openings are to be rounded, with a radius generally not less than $^1/_{24}$ of the breadth of the opening.

8.11 Pillars

8.11.1 Pillars are to be in the same vertical line as far as possible.

8.11.2 Pillars spaced at a distance exceeding the unsupported span (wide-spaced) are to be fitted in line with a keelson or double bottom girder; if infeasible, to be as close as is practicable.

8.11.3 The seatings under wide-spaced pillars are to be of ample strength and of a character which provides effective distribution of the load.

8.11.4 Where pillars are not directly above the intersection of the solid floor and intercostal girder, the partial floor and intercostal girder are to be fitted to support the pillar.

8.11.5 Manholes and lightening holes are not to be cut in the floor and girder below the heel of the pillar.

8.11.6 Where the heel of a pillar is carried on a tunnel, suitable arrangements are to be made to support the load.

8.11.7 Additional supports are to be arranged at the ends and corners of deckhouses, in machinery spaces, at the ends of partial superstructures and under heavily concentrated load areas.

8.11.8 The permissible load a pillar can carry is to be equal to or greater than the pillar load W, as determined in 8.11.9. The permissible load may be obtained from the following equation:

$$W_a = \left(k - \frac{n\,l}{r}\right) \cdot A$$

Where:

W_a = load, in kN,

k= 12.09 for ordinary steel,

n= 0.0444 for ordinary steel,

l= unsupported span length of the pillar, in cm,

r= least radius of gyration concerning the cross section of the pillar, in cm,

A= area of the cross section of the pillar, in cm^2.

8.11.9 The load on a pillar is to be obtained from the below equation:

$$W = n \cdot b \cdot h \cdot s$$

Where:

W = load, in kN,

n= 7.04,

b= mean breadth of area supported by the pillar, in m,

s= mean length of area supported by the pillar, in m,

h= height above the deck supported, in m, obtained from the following equation:

$$h = 0.1415 \cdot p$$

Where:

p= distributed pressure acting on the abovementioned deck which the pillar is located, in $kN/_{m^2}$. The minimum pressure values are given in Chapter 2.

8.11.10 Special consideration must be given to the load of the lower pillar when we have an upper pillar in line above the lower pillar.

8.11.11 Effective arrangements are to be made to distribute the load at the head and heel of each pillar.

8.11.12 Longitudinal and transverse brackets are to be fitted at the head and heel of pillars of built-up sections to ensure satisfactory distribution of loads.

8.11.13 Insert plates or doubling plates are to be fitted on the bottom and deck under heels of large pillars if there are no brackets to distribute the load.

8.11.14 Doubling plates are not to be fitted where pillars may be subjected to tension loads such as in the deep tank.

SECTION 9 Bulkheads

9.1 General

9.1.1 The following requirements apply to bulkheads with both vertical and horizontal framing systems.

9.1.2 Bulkheads, or part bulkheads, forming the boundary of tanks are to comply with the requirements of 9.5 and 9.6.

9.1.3 A centreline bulkhead is, generally, to be fitted in deep tanks which extend from side to side. The bulkhead may be intact or perforated as desired. If intact, the scantlings are to comply with the requirements of 9.5 and 9.6 for tank boundary bulkheads. If swash, they are to comply with the requirements of 9.10 for washplates.

9.2 Watertight bulkhead plating

9.2.1 The thickness of the watertight bulkhead plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{9} L} + 1 \right) \ mm \ or$$

$$2{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

9.3 Watertight bulkhead stiffening

9.3.1 The Rule requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressure from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 using the appropriate load model.

9.4 Deep tank plating

9.4.1 The thickness of deep tank plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{7} L} + 1{,}2 \right) \ mm \ or$$

$$3{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

9.5 Deep tank stiffening

9.5.1 Deep tank bulkhead stiffeners are to be bracketed at both ends. The thickness of the brackets is to be not less than the web thickness of the stiffener.

9.5.2 The Rule requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressure from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for load model (b).

9.6 Double bottom tanks

9.6.1 The scantlings of double bottom tanks are to comply with the requirements for deep tanks given in 9.4 and 9.5.

9.6.2 Where the bulkhead deck/ tank top of a double bottom tank forms a vehicle, passenger or other deck, the requirements of SECTION 8 are to be complied with.

9.7 Collision bulkheads

9.7.1 The scantlings of collision bulkheads are to be not less than as required for deep tank bulkheads contained in 9.4 and 9.5.

9.8 Non-watertight or partial bulkheads

9.8.1 Where a bulkhead is structural but non-watertight the scantlings are in general to be as for watertight bulkheads. Partial bulkheads that are non-structural are outside the scope of classification.

9.9 Corrugated bulkheads

9.9.1 The plating thickness and section modulus for symmetrical corrugated bulkheads are to be in accordance with watertight bulkheads or deep tank bulkheads as appropriate.

9.10 Wash plates

9.10.1 Tanks are to be subdivided as necessary by internal baffles or wash plates. Baffles or wash plates which support hull framing are to have scantlings equivalent to web frames in the same position.

9.10.2 Wash plates and wash bulkheads are, in general, to have an area of perforation not less than 10% of the total area of the bulkhead. The perforations are to be so arranged that the efficiency of the bulkhead as a support is not impaired.

9.10.3 The plate thickness is to be not less than the structural element from which the wash bulkhead is formed.

9.10.4 The general stiffener requirements are to be in accordance with 9.5. However, the section modulus may be 50% of that required by 9.5.

SECTION 10 Superstructures and deckhouses

10.1 Superstructure and deckhouse side plating

10.1.1 The thickness of house side plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{11} L} + 1 \right) \ mm \ or$$

$$2{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

10.2 Superstructure and deckhouse front plating

10.2.1 The thickness of the house front plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the below equations:

a) Superstructure and deckhouse front 1st tier plating:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{2}{9} L} + 1{,}5 \right) \ mm \ or$$

$$3{,}0 \ mm$$

b) Superstructure and deckhouse front upper tiers plating:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{2}{11} L} + 1{,}3 \right) \; mm \; or$$

$$3{,}0 \; mm$$

where:

L, k_2= as defined in 3.3.1.

10.3 Superstructure and deckhouse end plating

10.3.1 The thickness of the house end plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the below equations:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{25} L} + 0{,}6 \right) \; mm \; or$$

$$2{,}0 \; mm$$

where:

L, k_2= as defined in 3.3.1

10.4 Superstructure and deckhouse top plating

10.4.1 The thickness of the house top plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules.

10.5 Coachroof plating

10.5.1 The thickness of the coachroof plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules.

10.6 Machinery casing plating

10.6.1 The thickness of the plating of machinery casings is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules.

10.7 Forecastle requirements

10.7.1 The forecastle side plating may be a continuation of the hull side shell plating or fitted as a separate assembly. In both cases the plating thickness is to be the same as the side shell plating at deck edge. Where fitted as a separate assembly, suitable arrangements are to be made to ensure continuity of the effect of the sheerstrake at the break and at the upper edge of the forecastle side. Full penetration welding is to be used.

10.7.2 The side plating is to be stiffened by side frames effectively connected to the deck structure. Deep webs are to be fitted to ensure overall rigidity.

10.7.3 The deck plating thickness is to be increased by 20% in way of the end of the forecastle if this occurs at a position aft of $0{,}25 \cdot L$ from the F.P. No increase is required if the forecastle end bulkhead lies forward of $0{,}2 \cdot L$ from the F.P. The increase at intermediate positions of end bulkhead is to be obtained by interpolation.

10.8 Superstructure and deckhouse side stiffeners

10.8.1 The Rule requirements for section modulus, inertia and web area for the house side primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 5.3.5 for the load model (b).

10.9 Superstructure and deckhouse front stiffeners

10.9.1 The Rule requirements for section modulus, inertia and web area for house front primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.9.2 The Rule requirements for section modulus, inertia and web area for house front secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.10 Superstructure and deckhouse aft end stiffeners

10.10.1 The Rule requirements for section modulus, inertia and web area for house aft end primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.10.2 The Rule requirements for section modulus, inertia and web area for house aft end secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.11 Superstructure and deckhouse top stiffeners

10.11.1 The superstructure and deckhouse top is to be effectively supported by a system of transverse or longitudinal beams and girders. The span of the beams is in general not to exceed 2,4 metres and the beams are to be effectively connected to the house upper coamings and girders.

10.11.2 The Rule requirements for section modulus, inertia and web area for house top primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.11.3 The Rule requirements for section modulus, inertia and web area for house top secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.12 Coachroof stiffeners

10.12.1 The Rule requirements for section modulus, inertia and web area for coachroof primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.12.2 The Rule requirements for section modulus, inertia and web area for coachroof secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.13 Machinery casing stiffeners

10.13.1 The Rule requirements for section modulus, inertia and web area for machinery casing primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.13.2 The Rule requirements for section modulus, inertia and web area for machinery casing secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.14 Forecastle stiffeners

10.14.1 The scantlings of forecastle primary and secondary stiffening members are to be equivalent to those for the side shell envelope framing at the deck edge as required by SECTION 7.

10.15 Superstructures formed by extending side structures

10.15.1 Superstructure first tier sides formed by extending the hull side structure are to be in accordance with the requirements for house fronts given in 10.2 and 10.11 for plating and stiffeners respectively, but need not be taken as greater than the side structure requirements at the deck edge at the same longitudinal position.

10.16 Bulwarks

10.16.1 The thickness of the bulwark plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules.

10.16.2 Fishing craft are to have bulwarks fitted. The bulwark may be formed from a continuation of the side shell plating or connected as a separate assembly. Where the bulwark is considered to be stressed and contributing to the global strength of the craft, the plate thickness of the bulwark is not to be less than the sheerstrake plating thickness. In no case is the thickness of the bulwark plating to be taken as less than 80% of the side shell thickness.The bulwark is to be supported by suitable stiffening members which may be formed from a continuation of the side frames, or from flanged plate stays of the same thickness as the bulwark. In general these frames are to be spaced not more than two side frame spacings apart.

SECTION 11 Structural scantlings for multi-hull vessels-General principles and requirements

11.1 Application

11.1.1 The requirements of SECTION 11, SECTION 12, SECTION 13, SECTION 14, SECTION 15 and SECTION 16 are applicable to multi-hull craft of steel construction.

11.2 Direct calculations

11.2.1 In case the design, form or proportions of the craft are unusual, or the speed of the craft exceeds 60 knots, the scantlings are to be determined by direct calculation.

11.2.2 In any case direct calculations based on well-established principles of mechanics may be used alternatively or complementary to these Rules, provided that the achieved level of safety remains equivalent.

11.3 Symbols and definitions

11.3.1 The symbols used in this Section are defined below:

L= Rule length of craft, in metres,

s= stiffener spacing, in mm

σ_S= guaranteed minimum yield strength of the material, in N/mm²

$\tau_S = \sigma_S / \sqrt{3}$

k_1=high tensile steel factor

$= 235/\sigma_S$

$k_2 = 635/(\sigma_S+\sigma_U)$

σ_U= specified minimum ultimate tensile strength of the material, in N/mm²

t= plating thickness, in mm

11.3.2 Bottom outboard. For high speed craft, where the scantlings of the bottom shell are governed by impact pressure considerations, the bottom outboard shell is defined as the area of the hull between the outboard edge of the keel and the outer bilge tangential point. For displacement and semi displacement type craft where the scantlings of the bottom shell are governed by either hydrostatic or pitching pressures the bottom outboard shell is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

11.3.3 Bottom inboard. For high speed craft, where the scantlings of the bottom shell are governed by impact pressure considerations, the bottom inboard shell is defined as the area of the hull between the inboard edge of the keel and the inner bilge tangential point. For displacement and semi displacement type craft where the scantlings of the bottom shell are governed by either hydrostatic or pitching pressures the bottom inboard shell is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

11.3.4 Haunch. The haunch is defined as the transition area between the cross-deck and the inboard side shell plating.

11.3.5 Cross-deck. The cross-deck is defined as the structure which forms the bridge connection between any two adjacent hulls.

11.3.6 Side inboard. The side inboard is defined as the area between the bottom inboard shell and the wet-deck (or lower edge of the haunches, where fitted).

11.3.7 Side outboard. The side outboard is defined as the area between bottom outboard shell and the deck at side.

11.3.8 Wet-deck. The wet-deck is defined as the area between the upper edges of the side inboard plating (or upper edges of the haunches, where fitted).

SECTION 12 Single bottom structure and appendages

12.1 Keel

12.1.1 The scantlings and arrangements of plate keels are to be in accordance with 14.1.

12.1.2 Where fitted, the cross-sectional area, A, and thickness, t, of bar keels should not, in general, be taken as less than:

$$A = 0{,}75 \cdot L \cdot k_1 \ cm^2$$

$$t = \sqrt{k_1} \cdot (0{,}5 \cdot L + 2) \ mm$$

where:

L, k_1= as defined in 3.3.1.

12.2 Centre girder

12.2.1 Centerline girders are to be fitted throughout the length of each hull and are generally to be fitted in association with transverse frames, transverses supporting longitudinals or where the breadth of floors at the upper edge is greater than 1,5 m.

12.2.2 The web depth of the centre girder is, in general, to be equal to the depth of the floors at the centreline as specified in 12.4.3.

12.2.3 The web thickness, t, of the centre girder is to be taken as not less than the maximum value obtained by the below equations:

$$t = \sqrt{k_1} \cdot \left(3 \cdot \sqrt{\frac{1}{14}L + 1}\right) \; mm \; or$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14}L + 1}\right) \; mm \; or$$

$$4{,}0 \; mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

12.2.4 The face flat area, A, of the centre girder is to be not less than:

$$A = 0{,}22 \cdot L \cdot k_1 \; cm^2$$

where:

L, k_1= as defined in 3.3.1.

12.2.5 The face flat area of the centre girder outside 0,5 · L may be 80% of the value given in 12.2.4.

12.2.6 The face flat thickness, t, is to be not less than the thickness of the web.

12.2.7 The ratio of the width to thickness of the face flat is to be not less than eight but is not to exceed sixteen.

12.2.8 Additionally, the requirements of 15.8 for bottom inboard longitudinal primary stiffeners are to be complied with.

12.3 Side girders

12.3.1 Where the floor breadth at the upper edge exceeds 4,0 m side girders are to be fitted at each side of the centre girder such that the spacing between the side and centre girders or between the side girders themselves is not greater than 2 metres.

12.3.2 The web thickness, t, of side girder is to be taken as not less than the maximum value obtained by the below equations:

$$t = \sqrt{0{,}43 \cdot L \cdot k_1} \;\; mm \; or$$

$$t = \sqrt{k_2} \cdot \left(2 \cdot \sqrt{\frac{1}{11} L} + 0{,}8\right) \; mm \; or$$

$$3{,}5 \; mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

12.3.3 The face flat area and thickness of side girders are to comply with the requirements for plate floors as defined in 12.4.5 and 12.4.6.

12.3.4 Additionally, the requirements of 15.8 for bottom inboard longitudinal primary stiffeners are to be complied with.

12.4 Floors general

12.4.1 In transversely framed craft, floors are generally to be fitted at every frame and underneath each bulkhead.

12.4.2 In longitudinally framed craft, floors are, in general, to be fitted at every transverse web frame and bulkhead and generally at a spacing not exceeding 2 meters.

12.4.3 The overall web depth, d, of floors at the centerline, is not to be taken as less than:

$$d = 6{,}2 \cdot L + 50 \; mm$$

where:

L= as defined in 3.3.1.

12.4.4 The web thickness of plate floors, t, is to be not less than the maximum value obtained by the below equations:

$$t = \sqrt{k_1} \cdot (0{,}0034 \cdot d + 2{,}25) \cdot (0{,}001 \cdot s + 0{,}5) \;\; mm \; or$$

$$t = \sqrt{k_2} \cdot \left(2 \cdot \sqrt{\frac{1}{11} L} + 0{,}8\right) \; mm \; or$$

$$3{,}5 \; mm$$

where:

d= determined from 12.4.3

L, k_1, k_2, s = as defined in 3.3.1.

12.4.5 The face flat area, A, of floors is not to be taken as less than:

$$A = 0{,}11 \cdot L \cdot k_1 \ cm^2$$

where:

L, k_1= as defined in 3.3.1

12.4.6 The face flat thickness, t, is to be not less than the thickness of the web and the ratio of the web to the thickness of the face flat is to be not less than eight but is not to exceed sixteen.

12.4.7 Additionally, the requirements of 15.6 for bottom outboard transverse web frames are to be complied with.

12.5 Floors in machinery spaces

12.5.1 The web thickness, t, of floors in machinery spaces is to be 1 mm greater than that required by 12.4.4.

12.6 Forefoot and stem

12.6.1 The thickness of plate stems at the waterline is to comply with the requirements for plate keels as given in 14.1.

12.6.2 The cross-sectional area of bar stems, A, is not to be taken as less than:

$$A = 0{,}6 \cdot L \cdot k_1 \ cm^2$$

where:

L, k_1= as defined in 3.3.1.

SECTION 13 Double bottom structure

13.1 Keel

13.1.1 The scantlings of plate and bar keels are to comply with the requirements of 12.1.

13.2 Centre girder

13.2.1 A center girder is to be fitted throughout the length of the craft. The web thickness, t, is to be not less than the maximum value obtained by the below equations for each region:

- Within 0,4 · L amidships

$$t = \sqrt{k_1} \cdot (0{,}06 \cdot L + 3)\ mm\ or$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14}L + 1}\right)\ mm\ or$$

$$4{,}0\ mm$$

- At ends

$$t = \sqrt{k_1} \cdot (0{,}06 \cdot L + 2)\ mm\ or$$

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{2}L + 1}\right)\ mm\ or$$

$$4{,}0\ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

13.2.2 The overall web depth, d, of the center girder is to be taken as not less than 630 mm and is to be sufficient to give adequate access to all parts of the double bottom.

13.2.3 Additionally, the requirements of 15.8 for bottom inboard longitudinal primary stiffeners are to be complied with.

13.3 Side girders

13.3.1 The thickness of the side girder plating is not to be taken as less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(2 \cdot \sqrt{\frac{1}{11}L + 0{,}8}\right)\ mm\ or$$

$$3{,}5\ mm$$

where:

L, k_2= as defined in 3.3.1.

13.3.2 Where the floor breadth does not exceed 4,0 m, side girders are not required. Vertical stiffeners are to be fitted to the floors on each side, the number and positions of these stiffeners being dependent on the arrangement of the double bottom structure.

13.3.3 Where the breadth of floor is greater than 4,0 m, additional side girders having the same thickness as the floors are to be fitted. The number of side girders is to be such that the distance between the side girders and center girder and margin plate, or between the side girders themselves, does not exceed 2,0 meters.

13.4 Plate floors

13.4.1 The web thickness, t, of non-watertight plate floor is to be not less than the maximum of the following values:

$$t = \sqrt{k_1} \cdot (0{,}03 \cdot L + 3{,}5)\ mm\ or$$

$$t = \sqrt{k_2} \cdot \left(2 \cdot \sqrt{\frac{1}{11}L} + 0{,}8\right)\ mm\ or$$

$$3{,}5\ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

13.4.2 Additionally, the requirements of 15.6 for bottom outboard transverse web frames are to be complied with.

13.4.3 Plate floors are, in general, to be continuous between the center girder and the margin plate.

13.4.4 In longitudinally framed craft, plate floors are to be fitted in the following positions:

- At every half frame in way of the main engines, thrust bearings, and bottom of the craft forward.
- Outboard of the engine seatings, at every frame within the engine room.
- Underneath pillars and bulkheads.
- Outside of the engine room at a spacing not exceeding 2,0 m.

13.4.5 Vertical flat bar stiffeners are to be fitted to all plate floors at each longitudinal. Each stiffener is to have a depth of not less than $10 \cdot t$ and a thickness of not less than t, where t is the thickness of the plate floor as calculated in 13.4.1.

13.4.6 In transversely framed craft, plate floors are to be fitted at every frame in the engine room, under bulkheads, in way of change in depth of double bottom and elsewhere at a spacing not exceeding 2,0 m.

SECTION 14 Shell envelope plating

14.1 Keel plate

14.1.1 The breadth, b, and thickness, t, of plate keel are not to be taken as less than:

$$b = 5{,}0 \cdot L + 250 \ mm$$
$$t = 1{,}35 \cdot \sqrt{k_1} \cdot L^{0{,}45} \ mm$$

where:

L, k_1= as defined in 3.3.1.

14.1.2 In no case is the thickness of the keel to be less than that of the adjacent bottom shell plating.

14.2 Bottom outboard

14.2.1 The thickness of the bottom outboard plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{6} L} + 2{,}0 \right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.2.2 For all craft types, the minimum bottom outboard shell thickness requirement given in 14.2.1 is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

14.3 Bottom inboard

14.3.1 The thickness of the bottom inboard plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{6} L} + 2{,}0 \right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.3.2 For all craft types, the minimum bottom inboard shell thickness requirement given in 7.4 is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

14.4 Side outboard

14.4.1 The thickness of the side outboard plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{7} L} + 1{,}2 \right) \ mm \ or$$

$$3{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.5 Side inboard

14.5.1 The thickness of the side inboard plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{7} L} + 1{,}2 \right) \ mm \ or$$

$$3{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.6 Wet-deck

14.6.1 The thickness of the wet-deck plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{7} L} + 1{,}2 \right) \ mm \ or$$

$$3{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.6.2 Additionally, the thickness of the wet-deck plating is in no case to be less than the thickness of the side inboard shell plating determined from 14.5.

14.7 Transom

14.7.1 The scantlings and arrangements of the stern or transom are to be not less than that required for the adjacent bottom inboard or side outboard structure as appropriate.

SECTION 15 Shell envelope framing

15.1 General

15.1.1 The following requirements apply to longitudinally and transversely framed shell envelopes.

15.2 Bottom outboard longitudinal stiffeners

15.2.1 Bottom outboard longitudinal stiffeners are to be supported by transverse web frames, floors, bulkheads, or other primary structure, generally spaced not more than 2 meters apart.

15.2.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.3 Bottom outboard longitudinal primary stiffeners

15.3.1 Bottom outboard longitudinal primary stiffeners are to be supported by deep transverse web frames, floors, bulkheads, or other primary structure, generally spaced not more than 4 meters apart.

15.3.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.4 Bottom outboard transverse stiffeners

15.4.1 Bottom outboard transverse stiffeners are defined as local stiffening members which support the bottom shell.

15.4.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.5 Bottom outboard transverse frames

15.5.1 Bottom outboard transverse frames are defined as stiffening members which support the bottom shell.

15.5.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.6 Bottom outboard transverse web frames

15.6.1 Bottom outboard transverse web frames are defined as primary stiffening members which support bottom shell longitudinals.

15.6.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3,Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.7 Bottom inboard longitudinal stiffeners

15.7.1 The scantlings and arrangements for bottom inboard longitudinal stiffeners are to be determined in accordance with the procedures described in 15.2 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.8 Bottom inboard longitudinal primary stiffeners

15.8.1 The scantlings and arrangements for bottom inboard longitudinal primary stiffeners are to be determined in accordance with the procedures described in 15.3 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.9 Bottom inboard transverse stiffeners

15.9.1 The scantlings and arrangements for bottom inboard transverse stiffeners are to be determined in accordance with the procedures described in 15.4 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.10 Bottom inboard transverse frames

15.10.1 The scantlings and arrangements for bottom inboard transverse frames are to be determined in accordance with the procedures described in 15.5 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.11 Bottom inboard transverse web frames

15.11.1 The scantlings and arrangements for bottom inboard transverse web frames are to be determined in accordance with the procedures described in 15.6 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.12 Side outboard longitudinal stiffeners

15.12.1 The side outboard longitudinal stiffeners are to be supported by transverse web frames, bulkheads, or other primary structure, generally spaced not more than 2 meters apart.

15.12.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.13 Side outboard longitudinal primary stiffeners

15.13.1 Side outboard longitudinal primary stiffeners are to be supported by side transverse web frames, bulkheads, or other primary structure, generally spaced not more than 4 meters apart.

15.13.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.14 Side outboard transverse stiffeners

15.14.1 Side outboard transverse stiffeners are defined as local stiffening members supporting the side shell.

15.14.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.15 Side outboard transverse frames

15.15.1 Side outboard transverse frames are defined as stiffening members which support the side shell.

15.15.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.16 Side outboard transverse web frames

15.16.1 Side outboard transverse web frames are defined as primary stiffening members which support side shell longitudinals.

15.16.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.17 Side inboard longitudinal stiffeners

15.17.1 The scantlings and arrangements for side inboard longitudinal stiffeners are to be determined in accordance with the procedures described in 15.12 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.18 Side inboard longitudinal primary stiffeners

15.18.1 The scantlings and arrangements for side inboard longitudinal primary stiffeners are to be determined in accordance with the procedures described in 15.13 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.19 Side inboard transverse stiffeners

15.19.1 The scantlings and arrangements for side inboard transverse stiffeners are to be determined in accordance with the procedures described in 15.14 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.20 Side inboard transverse frames

15.20.1 The scantlings and arrangements for side inboard transverse stiffeners are to be determined in accordance with the procedures described in 15.16 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.21 Side inboard transverse web frames

15.21.1 The scantlings and arrangements for side inboard transverse stiffeners are to be determined in accordance with the procedures described in 15.15 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.22 Wet-deck longitudinal stiffeners

15.22.1 The wet-deck longitudinal stiffeners are to be supported by transverse web frames, bulkheads, or other primary structure, generally spaced not more than 2 meters apart.

15.22.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.22.3 In no case are the scantlings and arrangements for the wet-deck longitudinal stiffeners to be taken as less than those required for the side inboard longitudinal stiffeners detailed in 15.17.

15.23 Wet-deck longitudinal primary stiffeners

15.23.1 Wet-deck longitudinal primary stiffeners are to be supported by transverse web frames, bulkheads, or other primary structure, generally spaced no more than 4 meters apart.

15.23.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.23.3 In no case are the scantlings and arrangements for the wet-deck longitudinal primary stiffeners to be taken as less than those required for the side inboard longitudinal primary stiffeners detailed in 15.18.

15.24 Wet-deck transverse stiffeners

15.24.1 Wet-deck transverse stiffeners are defined as local stiffening members supporting the wet-deck.

15.24.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.24.3 In no case are the scantlings and arrangements for the wet-deck transverse stiffeners to be taken as less than those required for the side inboard transverse stiffeners detailed in 15.19.

15.25 Wet-deck transverse frames

15.25.1 Wet-deck transverse frames are defined as stiffening members which support the wet-deck.

15.25.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.25.3 In no case are the scantlings and arrangements for the wet-deck transverse frames to be taken as less than those required for the side inboard transverse frames detailed in 15.20.

15.26 Wet-deck transverse web frames

15.26.1 Wet-deck transverse web frames are defined as primary stiffening members which support wet-deck longitudinals.

15.26.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.26.3 In no case are the scantlings and arrangements for the wet-deck transverse web frames to be taken as less than those required for the side inboard transverse web frames detailed in 15.21.

SECTION 16 Deck structures

16.1 Cross-deck plating

16.1.1 The thickness of the cross-deck plating is to be determined from the general plating equation given in 3.10, using the design pressure from Part 3, Chapter 2 of the present Rules.

16.1.2 The thickness of the cross-deck plating is in no case to be less than the appropriate minimum requirements given below:

a) Strength/Main deck plating

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{7} L} + 1{,}2 \right) \; mm \; or$$

$$3{,}0 \; mm$$

b) Lower deck/Inside deckhouse plating

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{29} L} + 1{,}7 \right) \; mm \; or$$

$$2{,}0 \; mm$$

where:

L, k_2= as defined in 3.3.1.

16.2 Cross-deck stiffening

16.2.1 The Rule requirements for section modulus, inertia and web area for the cross-deck primary stiffeners are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

16.2.2 The Rule requirements for section modulus, inertia and web area of the strength / weather deck secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

SECTION 17 Bulkheads and deep tanks

17.1 Longitudinal bulkheads within the cross-deck structure

17.1.1 The scantlings and arrangements for cross deck longitudinal bulkheads are to be determined in accordance with the procedures described in 9.2 and 9.3 for bulkheads in mono-hull craft.

17.2 Transverse bulkheads within the cross-deck structure

17.1.2 The scantlings of cross deck transverse bulkheads are to be determined in accordance with the procedures described in 9.2 and 9.3 for bulkheads in mono-hull craft.

SECTION 18 Superstructures, deckhouses and bulwarks

18.1 General

18.1.1 The scantlings and arrangements for superstructures, deckhouses and bulwarks are to be determined in accordance with the procedures described in SECTION 10 for mono-hull craft.

CHAPTER 6 HULL CONSTRUCTION - ALUMINIUM

SECTION 1 General

1.1 General Requirements

1.1.1 The Rules apply to mono-hull and multi-hull vessels of normal form, speed and proportions. Despite the fact that the Rules refer to aluminum craft of all welded construction, other materials will be specially considered on the basis of the Rules.

1.2 Submitted Documentation

1.2.1 Documentation including the following particulars is to be submitted:

a) Profile and decks
b) Shell expansion
c) Propeller brackets
d) Midship sections showing longitudinal and transverse material
e) Pillars and girders
f) Oiltight and watertight bulkheads
g) Engine room construction
h) Engine and thrust seatings
i) Double bottom construction
j) Aft end construction
k) Hatch cover construction
l) Fore end construction
m) Deckhouses and superstructures
n) Sternframe
o) Equipment
p) Rudder, stock and tiller
q) Loading Manuals, preliminary and final (where applicable)
r) Welding schedule
s) Ice strengthening
t) Scheme of corrosion control (where applicable)
u) Bilge keels showing material grades, welded connections
v) Hull penetration plans
w) Support structure for masts, derrick posts or cranes

1.2.2 The following additional documentation are also to be submitted:

a) Capacity plan
b) Dry-docking plan
c) General arrangement
d) Lines plan or equivalent
e) Sail/rigging plan, indicating loadings (as applicable to sailing craft)
f) Towing and mooring arrangements

1.2.3 The following additional calculations are also to be submitted:
a) Calculation of hull girder still water and dynamic bending moments and shear forces as applicable
b) Calculation of equipment number
c) Freeboard calculation
d) Calculation of hull girder
e) Calculation of local strength (scantling’s check)

1.3 Exceptions

1.3.1 In case of craft which are not covered by the present Rules, such as craft of unsual form, speed or proportions, intended for the carriage of special cargoes, or for special or restricted service, they will be individually considered based on the general requirements of the Rules.

SECTION 2 Design and construction principles

2.1 Continuity and alignment

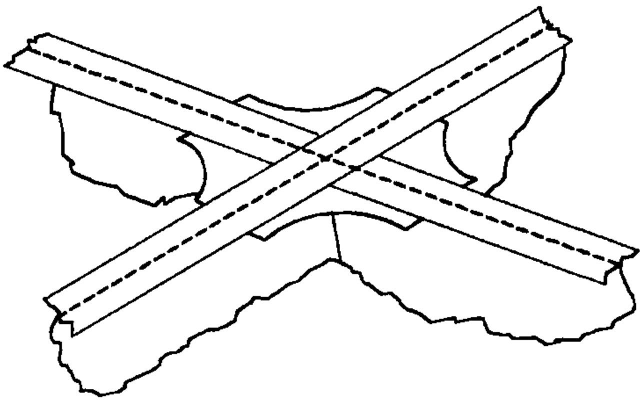
2.1.1 The arrangement of material is to be such as will ensure structural continuity. Abrupt changes of shape or section, sharp corners and points of stress concentration are undesirable and are to be avoided.

2.1.2 Where members abut on both sides of a bulkhead or similar structure, care is to be taken to ensure good alignment.

2.1.3 Pillars and pillar bulkheads are to be fitted in the same vertical line wherever possible, and elsewhere arrangements are to be made to transmit the out of line forces satisfactorily. The load at head and heel of pillars is to be effectively distributed and arrangements are to be made to ensure the adequacy and lateral stability of the supporting members.

2.1.4 Continuity is to be maintained where primary members intersect and where the members are of the same depth, a suitable gusset plate is to be fitted (see Figure 2.1.1).

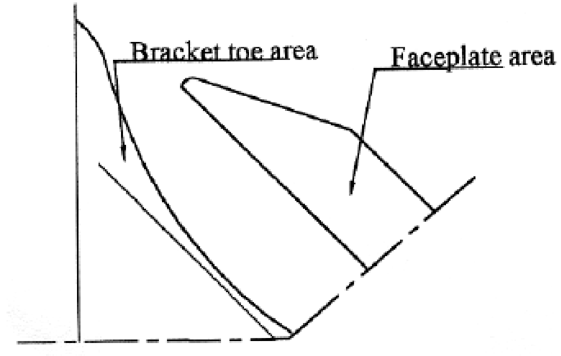
Figure 2.1.1: Primary member intersection



2.1.5 End connections of structural members are to provide adequate end fixity and effective distribution of the load into the supporting structure.

2.1.6 The stress concentrations can be minimized by paying particular attention to the design of the end bracket toes. Sniped face plates which are welded onto the edge of primary member brackets are to be carried well around the radiuses bracket toe and are to incorporate a taper not exceeding one in three. Adequate cross sectional area is to be provided through the bracket toe at the end of the snipe, in case sniped face plates are welded adjacent to the edge of primary member brackets. Generally, this area measured perpendicular to the face plate, is to be not less than 60% of the full cross-sectional area of the face plate (see Figure 2.1.2).

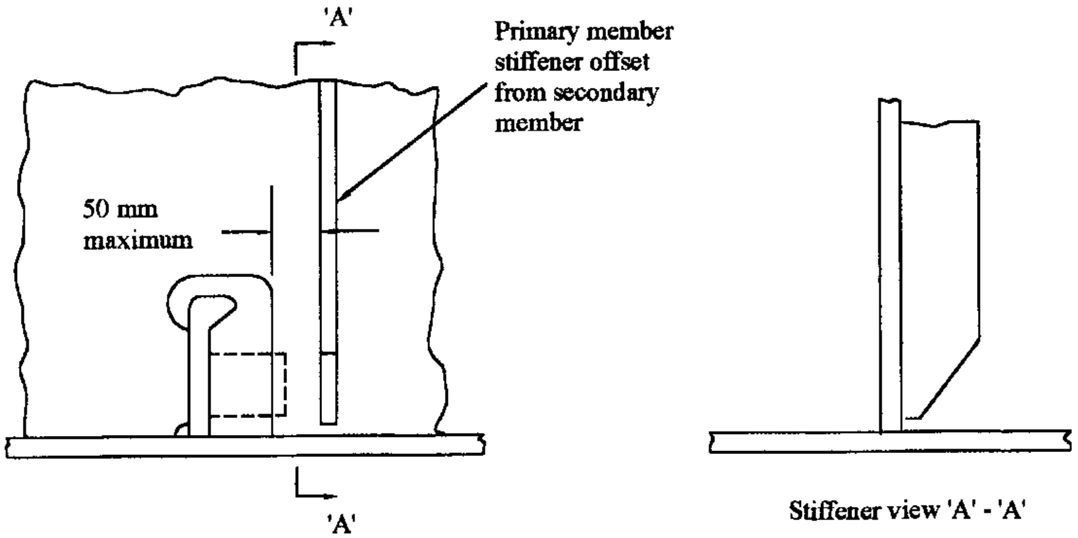
Figure 2.1.2: Bracket toe construction



2.2 Arrangement with offset stiffener

2.2.1 Where the stiffeners of the double bottom floors and transverse bulkheads are unconnected to the secondary members and offset from them (see Figure 2.2.1) the collar arrangement for the secondary members are to satisfy the requirements of 2.3. Moreover, the fillet welds attaching the lugs to the secondary members are to be based on a weld factor of 0,44 for the throat thickness. To facilitate access for welding the offset stiffeners are to be located 50 mm from the slot edge furthest from the web of the secondary member. The ends of the offset stiffeners are to be suitably tapered and softened.

Figure 2.2.1: Arrangement with offset stiffener



2.3 Arrangements at intersection of continuous secondary and primary members

2.3.1 In order to minimize stress concentrations around the perimeter of the opening and in the attached hull envelope or bulkhead plating, cut-outs for the passage of secondary members through the webs of primary members, and the related collaring arrangements, are to be designed. It is necessary to proceed to an investigation of the critical shear buckling stress of the panel, in which the cut-out is made. In high stress areas, the cut-outs for longitudinals are to have double lugs.

2.3.2 The cut-outs are to have a breadth as small as practicable, with the top edge suitably radiuses. Cut-outs are to have smooth edges, and the corner radii are to be as large as practicable, with a minimum of 20% of the breadth of the cut-out or 25 mm, whichever is the greater. It is suggested that the web plate connection to the hull envelope, or bulkhead, end in a smooth tapered 'soft toe'. In Figure 9.3.3 of Part 2, Chapter 9 of "Rules and Regulations for the Classification and Construction of Steel Ships" are shown recommended shapes of cut-out. However, consideration will be given to other shapes, in order to maintain equivalent strength and minimize stress concentration.

2.3.3 Symmetrical secondary members are to be connected by lugs on one or both sides, as necessary.

2.3.4 Asymmetrical secondary members are to be connected on the heel side to the primary member web plate. Additional connection by lugs on the opposite side may be required.

2.3.5 Where the primary member stiffener is connected to the secondary member it is to be aligned with the web of the secondary member, except where the face plate of the latter is offset and abutted to the web. In that case the stiffener connection is to be lapped.

2.3.6 Fabricated longitudinals, which may have the face plate welded to the underside of the web, leaving the edge of the web exposed, are not recommended for side shell and longitudinal bulkhead longitudinals. Where it is proposed to fit such sections, a symmetrical arrangement of connection to transverse members is to be incorporated. This can be achieved by fitting backing structure on the opposite side of the transverse web or bulkhead.

2.3.7 Where a bracket is fitted to the primary member web plate in addition to a connected stiffener it is to be arranged on the opposite side to, and in alignment with the stiffener. The arm length of the bracket is to be not less than the depth of the stiffener, and its cross-sectional area through the throat of the bracket is to be included in the calculation of the area of the primary web stiffener in way of the connection.

2.3.8 Alternative arrangements will be considered on the basis of their ability to transmit load with equivalent effectiveness. Testing procedures and details of the calculations made are to be submitted.

2.4 Openings

2.4.1 Manholes, lightening holes and other cut-outs are to be avoided in way of concentrated loads and areas of high shear. In particular, manholes and similar openings are not to be cut in vertical or horizontal diaphragm plates in narrow cofferdams or in floors and double bottom girders close to their span ends, or below the heels of pillars, unless the stresses in the plating and the panel buckling characteristics have been calculated and found satisfactory.

2.4.2 Manholes, lightening holes and other openings are to be suitably framed and stiffened where necessary.

2.4.3 Drain and air holes, scallops and notches are to be kept at least 200 mm clear of the toes of end brackets and other areas of high stress. Openings are to be well rounded with smooth edges. Closely placed scallops are not permitted. Widely spaced air or drain holes may be accepted, only if they have elliptical shape, or equivalent, to minimize stress concentration and are, in general, cut clear of the weld connection.

2.5 Openings in the web

2.5.1 Where openings are cut in the web, the depth of opening is not to exceed 50% of the web depth, and the opening is to be so located that the edges are not less than 25% of the web depth from the face plate. The length of opening is not to exceed the web depth or 60% of the secondary member spacing, whichever is the greater, and the ends of the openings are to be equidistant from the corners of cut-outs for secondary members. Where larger openings are proposed, the arrangements and compensation required will be specially considered. Openings are to have well rounded corners and smooth edges.

2.6 Tank boundary penetrations

2.6.1 Where structural members pass through the boundary of a tank, and leakage into the adjacent space could be hazardous or undesirable, full penetration welding is to be adopted for the members for at least 150 mm on each side of the boundary. Alternatively a small scallop of suitable shape may be cut in the member close to the boundary outside the compartment, and carefully welded all round.

2.7 Web stability

2.7.1 Primary members of asymmetrical section are to be supported by tripping brackets at alternate secondary members. If the section is symmetrical, the tripping brackets may be four spaces apart.

2.7.2 Tripping brackets are in general required to be fitted at the toes of end brackets and in way of heavy or concentrated loads such as the heels of pillars.

SECTION 3 Structural Scantlings for Mono-Hull Vessels – General Principles and Requirements

3.1 Application

3.1.1 The requirements of this Chapter are applicable to mono-hull craft of aluminium construction.

3.2 Direct calculations

3.2.1 In case the design, form or proportions of the craft are unsual, or the speed of the craft exceeds 60 knots, the scantlings are to be determined by direct calculation.

3.2.2 In any case direct calculations based on well established principles of mechanics may be used alternatively or complementary to these Rules, provided that the achieved level of safety remains equivalent.

3.3 Symbols and definitions

3.3.1 The following symbols are used in this chapter:

L= Rule length of craft, in meters, is the distance on the summer load waterline from the forward side of the stem to the after side of the rudder post or to the centre of the rudder stock if there is no rudder post. L is to be not less than 96%, and need not be greater than 97%, of the extreme length on the summer load waterline. In craft without rudders, the Rule length, L, is to be taken as 97% of the extreme length on the summer load waterline

B= moulded breadth of craft, in meters

I= moment of inertia, in cm^4

SM= section modulus of the stiffening member, in cm^3

A= shear area of stiffener web, in cm^2

p= design pressure, in kN/m^2

s= stiffener spacing, in mm

l= stiffener overall length, in meters

l_e= effective span length, in meters

K_{AR}= panel aspect ratio correction factor as defined in 3.9

t_p= plating thickness, in mm

K_c= convex curvature correction factor as defined in 3.8

σ_s= guaranteed minimum yield strength of the material, in N/mm^2

$\tau_s = \sigma_s/\sqrt{3}$

k_1= high tensile steel factor

$= 235/\sigma_s$

$k_2 = 635/(\sigma_s+\sigma_u)$

σ_u= specified minimum ultimate tensile strength of the material, N/mm^2

E= modulus of elasticity, in N/mm^2

3.4 Material properties

3.4.1 The basic grade of steel used in the determination of the Rule scantling requirements is taken as mild steel with the following mechanical properties:

Table 3.4.1: Material properties

0,2% proof stress (minimum)	125 N/mm^2
Tensile strength	260 N/mm^2
Modulus of elasticity	69 × 10^3 N/mm^2

3.4.2 Where alloys other than the basic one mentioned in 3.4.1 are used, then the Rule Requirements should be properly modified by taking into account the following material factors:

Table 3.4.2: Material factors

Alloy	k_1	k_2
5083-0 and F	1,00	1,00
5083-H321	0,58	0,75
5086-0 and F	1,32	1,15
5086-H112	1,14	1,1
5086-H321	0,64	0,83
6061-T6	0,52	0,73
6082-T6	0,52	0,73

3.5 High strength sheet and plate

3.5.1 The welding procedures for the welding of high strength sheet and plate are of great importance and should be taken into consideration. The 0,2% yield strength values in the welded condition will, in general, be significantly less than in the unwelded condition. These reduced values are to be used in the determination of the Rule scantlings.

3.6 High strength extrusions

3.6.1 High strength extrusions are generally used in superstructures, deckhouses, decks and bulkheads. Special consideration will be given to their use in other areas.

3.6.2 Butt welds and seams are to be carefully positioned clear of areas of high stress and where practicable are to be orientated parallel to the direction of the main stresses.

3.7 Effective width of attached plating

3.7.1 In case of primary support members the effective width of the attached plating may be taken equal to one-half of the sum of the spacings between parallel adjacent members or equivalent support.

3.7.2 In case of secondary stiffening members the effective width of the attached plating may be taken as:

$$2 \cdot t_p \cdot \sqrt{\frac{E}{\sigma_\alpha}}\ mm,$$

but not greater than the actual spacing of the stiffeners. In the above formula σ_a is not to be taken greater than 160 N/mm^2.

3.7.3 Where the web of the stiffener intersects the actual plating at an angle less than 70º the properties of the section are to be determined about an axis parallel to the attached plating.

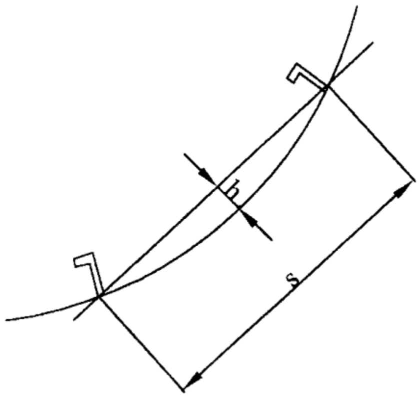
3.8 Consideration of convex curvature

3.8.1 For panels exhibiting significant curvature, the following reduction coefficient is to be taken into account:

$$K_c = 1 - \frac{h}{s}$$

without being less than 0,75, where distances h and s are defined in Figure 3.8.1.

Figure 3.8.1: Convex curvature



3.9 Aspect ratio correction

3.9.1 The thickness of plating as determined by the Rules may be reduced when the panel aspect ratio is taken into consideration. In such cases a panel aspect ratio correction factor may be applied:

$$K_{AR} = A_R \cdot (1 - 0{,}25 \cdot A_R) \text{ for } A_R \leq 2$$
$$K_{AR} = 1 \text{ for } A_R > 2$$

where:

K_{AR}= aspect ratio correction factor
A_R= panel aspect ratio
= panel length/panel breadth

3.10 General plating thickness

3.10.1 The thickness of plating, t, is, in general to be in accordance with the following formula:

$$t = 0{,}0225 \cdot s \cdot K_c \cdot K_{AR} \cdot \sqrt{\frac{p}{\sigma}}, \qquad mm$$

where:

σ = limiting bending stress value for the plating element under consideration given in Table 3.11.1

s, K_c, K_{AR}, p, σ_a = as defined in 3.3.1.

3.11 Stiffening general

3.11.1 The requirements for section modulus, inertia and web area stiffening members are in general to be in accordance with the following:

a) Section modulus:

$$SM = C_{SM} \cdot \frac{p \cdot s \cdot {l_e}^2}{\sigma}\ cm^3$$

where:

C_{SM} = section modulus coefficient dependent on the loading model assumption taken from Table 3.14.2
σ = limiting bending stress value for stiffening member given in Table 3.11.1
p, s, l_e and σ_s = as defined in 3.3.1.

b) Inertia:

$$I = C_I \cdot f_\delta \frac{p \cdot s \cdot {l_e}^3}{E} \cdot 10^4, cm^4$$

where:

C_I = inertia coefficient dependent on the loading model assumption taken from Table 3.14.2,
f_δ = limiting deflection value for stiffener member given in Table 3.11.2,
p, s, l_e and E = as defined in 3.3.1.

c) Web area:

$$A = C_A \cdot \frac{p \cdot s \cdot l_e}{100 \cdot \tau}\ cm^2$$

where:

C_A = web area coefficient dependent on the loading model assumption taken from Table 3.14.2,
τ = limiting shear stress value for stiffener member given in Table 3.11.1,
p, s, l_e and τ_s = as defined in 3.3.1.

Table 3.11.1: Limiting stress coefficients for local loading (to be continued)

Item		Limiting stress value		
		Bending stress σ	Shear stress τ	Equivalent stress
Shell envelope				
Bottom shell plating	- slamming zone	$0{,}85 \cdot \sigma_s$	-	-
	- elsewhere	$0{,}75 \cdot \sigma_s$	-	-
Side shell plating	- slamming zone	$0{,}85 \cdot \sigma_s$	-	-
	- elsewhere	$0{,}75 \cdot \sigma_s$	-	-
Keel		$0{,}75 \cdot \sigma_s$	-	-
Bottom structure				
Secondary stiffening	- slamming zone	$0{,}75 \cdot \sigma_s$	$0{,}75 \cdot \tau_s$	
	- elsewhere	$0{,}65 \cdot \sigma_s$	$0{,}65 \cdot \tau_s$	
Primary girders and web frames		$0{,}65 \cdot \sigma_s$	$0{,}65 \cdot \tau_s$	$0{,}75 \cdot \sigma_s$
Engine girders		$0{,}55 \cdot \sigma_s$	$0{,}55 \cdot \tau_s$	$0{,}75 \cdot \sigma_s$

Side structure			
Secondary stiffening - slamming zone	$0,75 \cdot \sigma_s$	$0,75 \cdot \tau_s$	
- elsewhere	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	
Primary girders and web frames	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	$0,75 \cdot \sigma_s$
Bow doors			
Plating	$0,65 \cdot \sigma_s$		
Secondary stiffening	$0,51 \cdot \sigma_s$	$0,433 \cdot \tau_s$	
Primary stiffening	$0,51 \cdot \sigma_s$	$0,34 \cdot \tau_s$	$0,64 \cdot \sigma_s$
Main / strength deck plating and stiffeners			
Plating	$0,75 \cdot \sigma_s$		
Secondary stiffening	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	
Primary girders and web frame	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	$0,75 \cdot \sigma_s$
Hatch covers	$0,55 \cdot \sigma_s$	$0,55 \cdot \tau_s$	$0,64 \cdot \sigma_s$
Superstructures / deckhouses			
Deckhouse front 1st tier - plating	$0,65 \cdot \sigma_s$	-	-
- stiffening	$0,60 \cdot \sigma_s$	$0,60 \cdot \tau_s$	-
Deckhouse front upper tiers - plating	$0,75 \cdot \sigma_s$		
- stiffening	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	-
Deckhouse aft and sides - plating	$0,75 \cdot \sigma_s$		
- stiffening	$0,75 \cdot \sigma_s$	$0,75 \cdot \tau_s$	-
Coachroof - plating	$0,65 \cdot \sigma_s$		
- stiffening	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	-
House top - plating	$0,75 \cdot \sigma_s$		
- stiffening	$0,75 \cdot \sigma_s$	$0,75 \cdot \tau_s$	-
Lower/inner decks and house top subject to personnel loading	$0,75 \cdot \sigma_s$		
- plating	$0,60 \cdot \sigma_s$	$0,60 \cdot \tau_s$	-
- stiffening			-
Bulkheads			
(a) Collision bulkhead - plating	$0,75 \cdot \sigma_s$	-	-
- secondary stiffening	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	-
- primary stiffening	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	$0,75 \cdot \sigma_s$
(b) Watertight bulkhead - plating	$1,00 \cdot \sigma_s$	-	-
- secondary stiffening	$0,95 \cdot \sigma_s$	$0,95 \cdot \tau_s$	-
- primary stiffening	$0,90 \cdot \sigma_s$	$0,90 \cdot \tau_s$	$1,00 \cdot \sigma_s$
Watertight bulkhead doors	$0,825 \cdot \sigma_s$	$0,825 \cdot \tau_s$	-
Structure supporting watertight doors	$0,80 \cdot \sigma_s$	$0,80 \cdot \tau_s$	-
(c) Minor bulkheads - plating	$0,65 \cdot \sigma_s$	-	-
- secondary stiffening	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	-
- primary stiffening	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	$0,75 \cdot \sigma_s$
(d) Deep tank bulkheads - plating	$0,65 \cdot \sigma_s$	-	-
- secondary stiffening	$0,65 \cdot \sigma_s$	$0,65 \cdot \tau_s$	-
- primary stiffening	$0,75 \cdot \sigma_s$	$0,75 \cdot \tau_s$	-

Table 3.11.2: Limiting deflection ratio

Item		Deflection ratio, f_δ
Bottom structure		
	- secondary stiffening	4,75
	- primary girders and web frames	6,25
Side structure		
	- secondary stiffening	4,75
	- primary girders and web frames	6,25
Main/strength deck structures		
	- secondary stiffening	6,25
	- primary girders and web frames	7,75
	- hatch covers	7,75
Superstructures/deckhouses stiffeners		
Generally	- secondary	4,00
	- primary	4,75
Coachroof	- secondary	4,75
	- primary	6,25
House top	- secondary	4,00
	- primary	4,00
Lower/inner decks and house top subject to personnel loading		
	- secondary members	4,75
	- primary members	6,25
Deep tank structures		
Stiffeners	- secondary members	5,50
	- primary members	6,25
Watertight bulkhead structures		
Stiffeners	- secondary members	4,00
	- primary members	4,75

3.12 Geometric properties and proportions of stiffener section

3.12.1 In order to avoid structural instability and appearance of local buckling, the proportions of stiffening members are in general to be in accordance with the requirements of paragraphs 3.12.2, 3.12.3, 3.12.4, 3.12.5 & 3.12.6.

3.12.2 In case of flat bars the minimum web thickness should be greater than 1/15 of the web depth and always greater than 3 mm.

3.12.3 Where rolled or built sections are used the minimum web thickness should be at least equal to 1/50 of the web depth and always greater than 3 mm. In this case the width of the unsupported face plate or flanges should not be greater than 16 times the thickness of the face plate or flange.

3.12.4 The dimensions of a flat bar stiffener must comply with the following requirement:

$$\frac{h_w}{t_w} \leq 20 \cdot \sqrt{k}$$

Where:

h_w= flat bar height, in mm.

t_w= flat bar thickness, in mm.

k= see Part 3, Chapter 3, Paragraph 3.1.1.

3.12.5 The dimensions of a T-section stiffener are to comply with the following requirements:

$$\frac{h_w}{t_w} \leq 55 \cdot \sqrt{k}$$

$$\frac{b_f}{t_f} \leq 33 \cdot \sqrt{k}$$

$$b_f\ t_f \geq \frac{h_w\ t_w}{6}$$

Where:

h_w= web height, in mm.

t_w= web thickness, in mm.

b_f = flange width, in mm.

t_f = flange thickness, in mm.

k= see Part 3, Chapter 3, Paragraph 3.1.1.

3.12.6 The dimensions of an angle stiffener are to comply with the following requirements:

$$\frac{h_w}{t_w} \leq 55 \cdot \sqrt{k}$$

$$\frac{b_f}{t_f} \leq 16{,}50 \cdot \sqrt{k}$$

$$b_f\ t_f \geq \frac{h_w\ t_w}{6}$$

Where:

h_w= web height minus the flange thickness, in mm.

t_w= web thickness, in mm.

b_f = flange width minus the web thickness, in mm.

t_f = flange thickness, in mm.

k= see Part 3, Chapter 3, Paragraph 3.1.1.

3.13 Effective span length

3.13.1 The effective length of span of a stiffening member depends on length of the member and the design of each end connections. In general, the effective length of span is always equal or less than the physical length of the member.

3.13.2 The effective length of span of primary supporting members is the distance between the two span points, which should be taken at a distance b_e from each end of the member, where b_e is defined as follows:

$$b_e = b_d \left(1 - \frac{d_w}{d_b}\right)$$

where:

b_e, b_b, d_w and d_b = as shown in Figure 3.14.1.

3.13.3 The effective length of span of rolled or built up secondary stiffening members is the distance between the two span points, which in this case should be taken at the point where the depth of the end bracket, measured from the face of the secondary stiffening member, is equal to the depth of the member, see Figure 3.14.1. Where there is no end bracket, the span point is to be measured between primary member webs.

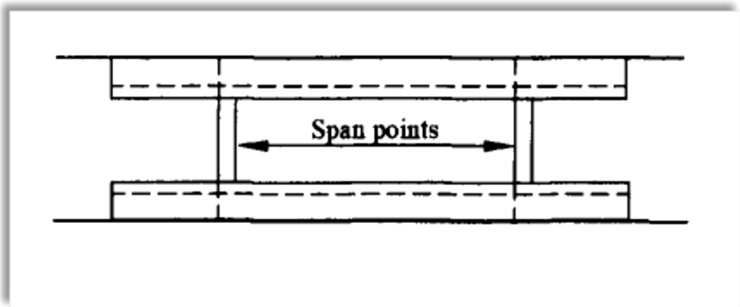
3.13.4 Where the stiffening member is curved then the span is to be taken as the effective chord length between span points.

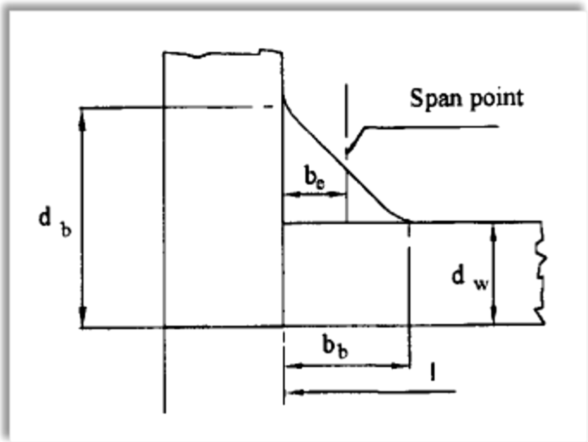
3.14 End brackets

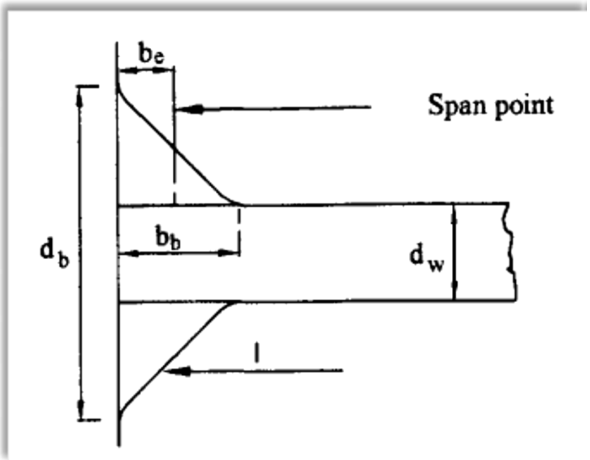
3.14.1 Where a longitudinal strength member is cut at a primary support and the continuity of strength is provided by brackets, the scantlings of the end brackets are to be such that their section modulus and effective cross-sectional area are not less than those of the member.

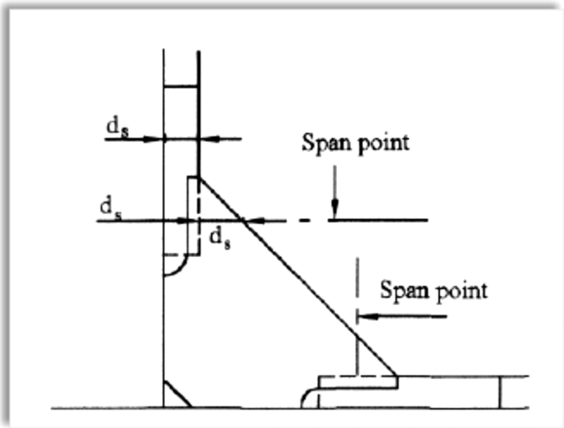
3.14.2 In other cases the scantlings of the bracket are to be based on the modulus, according to the Table 3.14.1.

Figure 3.14.1: Span points









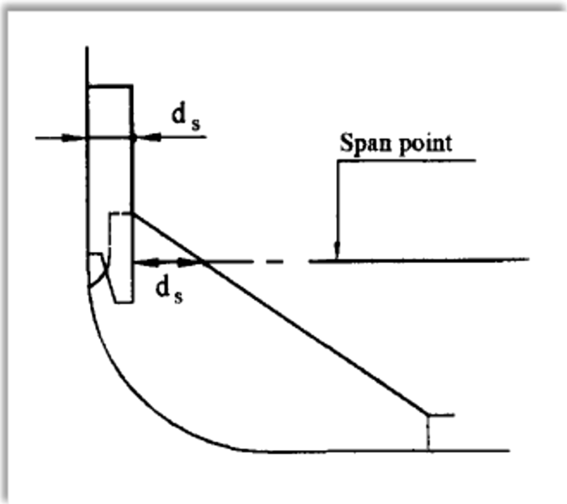
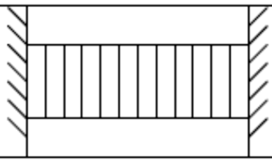
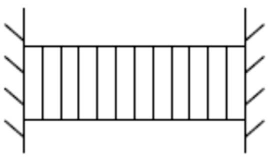
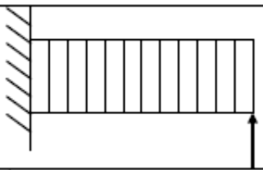
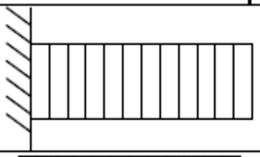
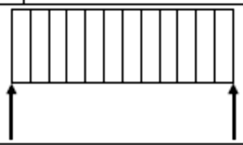


Table 3.14.1: Section modulus of brackets

Location of the bracket	Section Modulus of the bracket
Bracket at the head of a main transverse frame where frame terminates	modulus of the frame
Bracket connecting stiffener to primary member	modulus of the stiffener
Brackets connecting lower deck beams or longitudinals to the main frame in the forward 0,5L	modulus of the frame
Elsewhere	the lesser modulus of the members being connected by the bracket

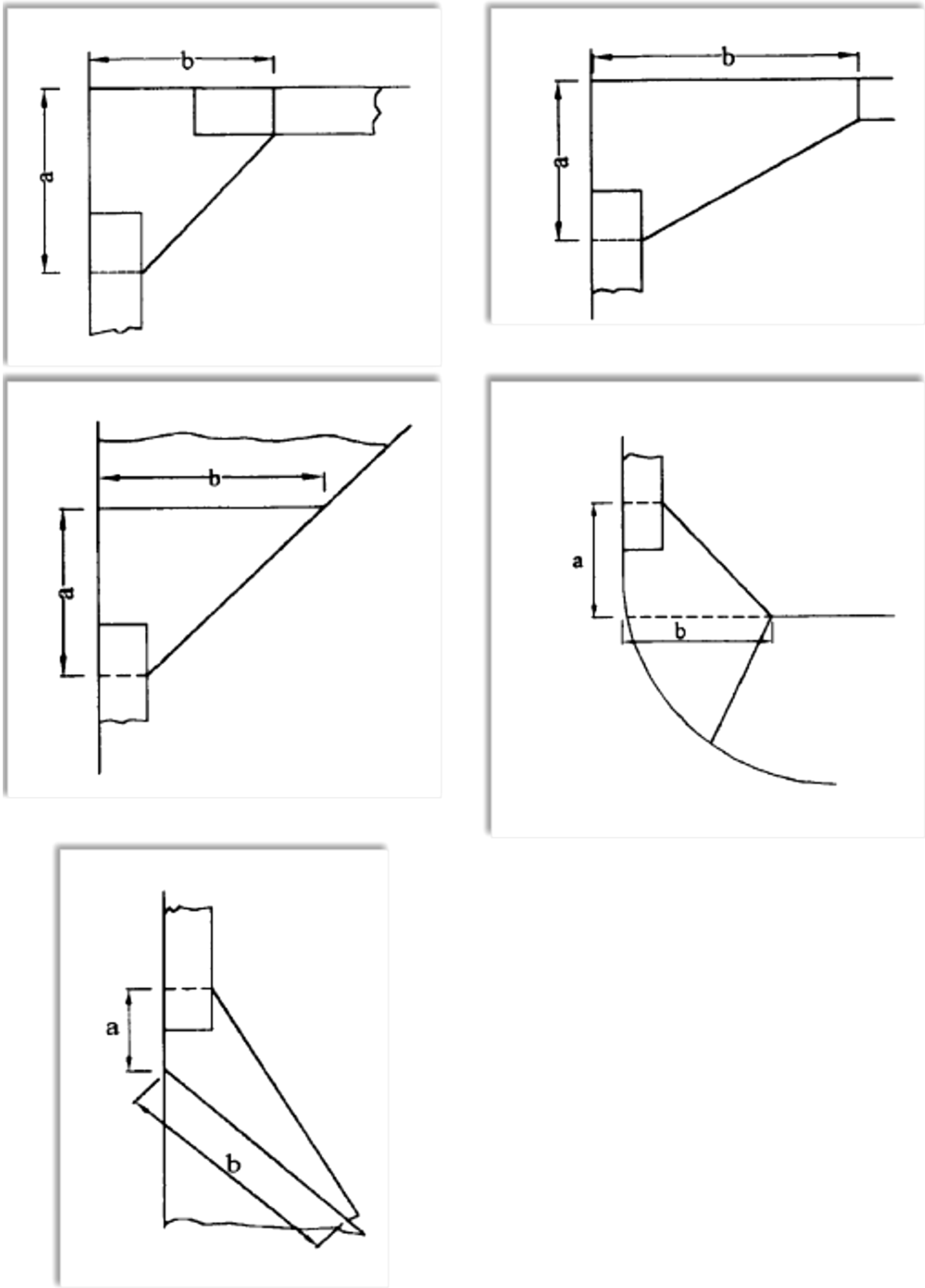
Table 3.14.2: Section modulus, inertia and web area coefficients

Load Model	Position 1 2 3	Position	Web area coefficient C_A	Section modulus coefficient C_{SM}	Inertia coefficient C_I	Application
(a)		1 2 3	1/2 - 1/2	1/12 1/24 1/12	- 1/384 -	Primary and other members where the end fixity is considered encastre
(b)		1 2 3	1/2 - 1/2	1/10 1/10 1/10	- 1/288 -	Local, secondary and other members where the end fixity is considered to be partial
(c)		1 2 3	5/8 - 3/8	1/8 9/128 -	- 1/185 -	Various
(d)		1 2 3	1 - -	1/2 - -	- - 1/8	Various
(e)		1 2 3	1/2 - 1/2	- 1/8 -	- 5/384 -	Hatch covers,glazing and other members where the ends are simply supported

3.14.3 The web thickness and face flat area of end brackets are not in general to be less than those of the connecting stiffeners. In addfition to this, the stiffener proportion requirements of 3.12 are to be satisfied.

3.14.4 In Figure 3.14.2 are shown diagrammatically typical arrangements of stiffener end brackets.

Figure 3.14.2: Stiffener end brackets



3.14.5 The lengths, a and b of the arms are measured from the plating to the toe of the bracket and are to be such that:

$$\alpha \geq 0{,}8 \cdot l_b$$
$$b \geq 0{,}8 \cdot l_b$$
$$\alpha + b \geq 2{,}0 \cdot l_b$$

where a and b are the actual lengths of the two arms of the bracket, in mm, measured from the plating to the toe of the bracket.

$$l_b = 90 \cdot \left(2 \cdot \sqrt{\frac{SM}{(14+\sqrt{SM})}} - 1\right) mm$$

where:

SM= the section modulus of the secondary member, in cm³

l_b should not be taken as less than twice the web depth of the stiffener on which the bracket scantlings are to be based.

3.14.6 Where any of the following apply, the free edge of the bracket is to be stiffened:
a) The bracket is fitted at the lower end of main transverse side framing.
b) The section modulus, SM, exceeds 500 cm³.
c) The length of free edge exceeds 40 times the bracket thickness.

3.14.7 Where a face flat is fitted, its breadth, b_f, is to be not less than:

$$b_f = 30 \cdot \left(1 + \frac{SM}{1000}\right) mm$$

but not less than 40 mm.

3.14.8 Where the stiffening member is lapped onto the bracket, the length of overlap is not to be less than $10\sqrt{SM}$, or the depth of stiffener, whichever is the greater.

3.14.9 Where the edge is stiffened by a welded face flat, the cross-sectional area of the face flat is to be not less than:

a) $0{,}017 \cdot k_1 \cdot b_f \cdot T_B$ cm² for offset edge stiffening.

b) $0{,}014 \cdot k_1 \cdot b_f \cdot T_B$ cm² for symmetrically placed stiffening.

where:

T_B= the thickness of the bracket, in mm

b_f= breadth of face flat, in mm

k_1= as defined in 3.3.1

3.14.10 Where the free edge of the bracket is hollowed out, it is to be stiffened or increased in size to ensure that the modulus of the bracket through the throat is not less than that of the required straight edged bracket.

3.14.11 The arrangement of the correction between the stiffener and the bracket is to be such that at no point in the connection is the actual modulus reduced to less than that of the stiffener with associated plating.

3.15 Primary member end connections

3.15.1 The scantling requirements for primary member end connections in dry spaces and in tanks of all craft types are generally to comply with the requirements of 3.14, taking SM as the section modulus of the primary member.

3.15.2 Primary members must have adequate lateral stability and web stiffening. Furthermore, the structure is to be arranged in such a way to minimize hard spots and other sources of stress concentration. The openings are to have smooth edges and well rounded corners and are to be located having regard to the stress distribution and buckling strength of the panel.

3.15.3 Primary members are to be arranged in such a way to ensure effective continuity of strength, and abrupt changes of depth or section are to be avoided. Where members abut on both sides of a bulkhead, or on other members, arrangements are to be made to ensure that they are in alignment. Primary members in tanks are to form a continuous line of support and wherever possible, a complete ring system.

3.15.4 Primary members are to be provided with adequate end fixity by end brackets or equivalent structure. The design of end connections and their supporting structure is to be such as to provide adequate resistance to rotation and displacement of the joint and effective distribution of the load from the member.

3.15.5 Where primary members are subject to concentrated loads, particularly if these are out of line with the member web, additional strengthening may be required.

3.15.6 Where the primary member is supported by structure which provides only a low degree of restraint against rotation, the member is generally to be extended beyond the point of support and thereafter tapered and/or scarfed into the adjacent structure over a distance generally not less than two frame spaces.

3.15.7 The thickness of the bracket is to be not less than that of the primary member web. The free edge of the bracket is to be stiffened.

3.15.8 Where a member is continued over a point of support, such as a pillar or pillar bulkhead stiffener, the design of the end connection is to be such as to ensure the effective distribution of the load into the support.

3.15.9 Where a deck girder or transverse is connected to a vertical member on the shell or bulkhead, the scantlings of the latter may be required to be increased to provide adequate stiffness to resist rotation of the joint.

3.15.10 Connections between primary members forming a ring system are to minimize stress concentrations at the junctions. Integral brackets are generally to be radiuses or well-rounded at their toes. The arm length of the bracket, measured from the face of the member, is to be not less than the depth of the smaller member forming the connection.

3.16 Secondary member end connections

3.16.1 Secondary members, such as, beams, longitudinals, frames and bulkhead stiffeners forming part of the hull structure, are to be effectively continuous and are to be suitably bracketed at their end connections.

SECTION 4 Single bottom structure

4.1 Single bottom structure and appendages

4.1.1 The following requirements apply to ships with single bottom construction in association with transverse and longitudinal framing systems.

4.2 Keel

4.2.1 The breadth, and thickness of plate keels are to comply with the requirements of 6.2.

4.2.2 The cross-sectional area, A, and thickness, t, of bar keels are not, in general, be taken as less than:

$$A = k_1 \cdot (1{,}85 \cdot L + 2) \; cm^2$$
$$t = \sqrt{k_1} \cdot (0{,}7 \cdot L + 8{,}25) \; mm$$

where:

L, k_1= as defined in 3.3.1.

4.3 Centre keelson

4.3.1 A center keelson is to be fitted throughout the length of the hull in association with transverse frames, transverses supporting longitudinals or where the breadth of floors at the upper edge is greater than 1,5 m.

4.3.2 Centre keelsons are to be formed of intercostal or continuous plate webs with a face plate welded to the upper edge. The face plate should be continuous. Where girder webs are intercostal, additional bracketing and local reinforcement will be required to maintain the continuity of structural strength.

4.3.3 The web depth of the center keelson is, in general, to be equal to the depth of the floors at the centerline as specified in 4.5.3.

4.3.4 The web thickness t is to be taken not less than the greater of the following values:

$$t = 1{,}4 \cdot \sqrt{k_1} \cdot \left(\sqrt{L} + 1\right) \ mm \ or$$

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{5}{4}L} + 1{,}4\right) \ mm \ or$$

$$5{,}0 \ mm$$

where:

L, k_1, k_2 = as defined in 3.3.1.

4.3.5 The cross sectional area of the face plate of the center girder A, is to be not less than:

$$A = 0{,}56 \cdot L \cdot k_1 \ cm^2$$

4.3.6 The face flat area of the center girder outside 0,5·L amidships may be 80% of the value given in 4.3.5.

4.3.7 The thickness of the face plate is not to be less than the thickness of the web.

4.3.8 The ratio of the width to thickness of the face plate is to be not less than eight but should not exceed sixteen.

4.3.9 Additionally, the requirements of 7.3 for bottom longitudinal primary stiffeners are to be complied with.

4.4 Side girders

4.4.1 Where the floor breadth at the upper edge exceeds 6,0 m, side girders are to be fitted at each side of the centre girder such that the spacing between the side and centre girders or between the side girders themselves is not greater than 3 metres. Side girders where fitted are to extend as far forward and aft as practicable and are, in general, to terminate in way of bulkheads, deep floors or other primary transverse structure.

4.4.2 The web thickness of side girders is to be taken as not less than the greater of the following values:

$$t = 1{,}4 \cdot \sqrt{k_1 \cdot L} \ mm$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14}L} + 1{,}1\right) \ mm \ or$$

$$4{,}0 \ mm$$

where:

L, k_1, k_2=as defined in 3.3.1.

4.4.3 The cross sectional area of the face plate and the thickness of side girders are to comply with the requirements for plate floors as defined in 4.5.6 and 4.5.7.

4.4.4 Watertight side girders, and side girders forming the boundaries of tank spaces, are also to comply with the requirements for watertight bulkheads and deeptanks as detailed in 9.3 and 9.5.

4.5 Floors general

4.5.1 In transversely framed craft, plate floors are generally to be fitted at each frame and underneath every bulkhead.

4.5.2 In longitudinally framed craft, plate floors are to be fitted at every transverse web frame and bulkhead and generally at a spacing not exceeding 2 m. Additional transverse floors or webs are in general to be fitted at half web-frame spacing in way of engine seatings and thrust bearings, pillars, skegs, ballast /bilge keels and the bottom of the craft forward.

4.5.3 The overall depth, d_f, of plate floors at the centerline is not to be taken as less than:

$$d = 40 \cdot B + 35 \cdot D \; mm, \quad when\ B < 10\ m,$$

$$d = 65 \cdot B + 35 \cdot D - 200\ mm, \quad when\ B \geq 10\ m,$$

where:

D= the depth.

4.5.4 The web thickness, t, of plate floors, is to be in accordance with 3.12 and is to be taken as not less than the greater of the following values:

$$t = \sqrt{k_1} \cdot (0{,}0047 \cdot d) \cdot (0{,}001 \cdot s)\ mm$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14} L + 1{,}1}\right) mm\ or$$

$$4{,}0\ mm$$

where:

d= to be determined from 4.5.3,
k_1, k_2, s= as defined in 3.3.1.

4.5.5 If the side frames of the craft are attached to the floors by brackets, the depth of floor may be reduced by 15% and the floor thickness determined using the reduced depth. PHRS may accept alternatives to requirements given in 4.5.3, provided they are deemed to be equivalent. The brackets are to be flanged and have the same thickness as the floors, and their arm lengths clear of the frame are to be the same as the reduced floor depth given above.

4.5.6 The cross sectional area of the face plate, A, is not to be taken as less than:

$$A = 0{,}28 \cdot L \cdot k_1 \ cm^2$$

where:

k_1, L= as defined in 3.3.1.

4.5.7 The thickness of the face plate is to be not less than the thickness of the web and the ratio of the width to the thickness of the face flat is to be not less than eight but is not to exceed sixteen.

4.5.8 Additionally the requirements of 7.6 for bottom transverse web frames are to be complied with.

4.5.9 Floors are generally to be continuous from side to side.

4.5.10 The floors in the aft peak are to extend over and provide effective support to the stern tube(s) where applicable.

4.5.11 Watertight floors, or floors forming boundaries of tank spaces, are also to comply with the requirements for watertight bulkheads or deeptanks as detailed in 9.3 and 9.5.

4.6 Floors in machinery spaces

4.6.1 The thickness, t, of the floors in machinery spaces is to be 1mm greater than that required by 4.5.4.

4.6.2 The depth and section modulus of floors anywhere between engine or gearbox girders is to be not less than that required to maintain continuity of structural integrity or 50% of the depth given in 4.5.3.

4.7 Rudder horns

4.7.1 The scantlings of the rudder horn are to be such that the section modulus against transverse bending at any horizontal section XX (see Figure 4.7.1) is not less than:

$$SM = 2{,}8 \cdot k_1 \cdot R_A \cdot K_v \cdot (V+3)^2 \cdot \sqrt{(a^2 + 0{,}5 \cdot b^2)} \ cm^3$$

where:

R_A= total rudder area, in m²

V= maximum speed in the fully loaded condition, in knots

K_v= 1,0 for displacement craft with $\frac{V}{\sqrt{L_{WL}}} < 3$

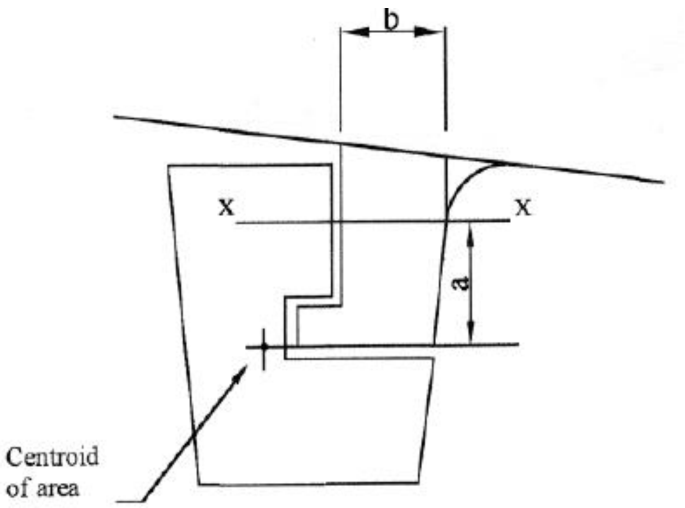
= $(1{,}12 - 0{,}005 \cdot V)^3$ for planing and semi-planing craft with $\frac{V}{\sqrt{L_{WL}}} \geq 3$

a, b= dimensions, in meters, as given in Figure 4.7.1.

L_{WL}= waterline length

4.7.2 The shell plating thickness in way of the rudder horn does not need to be taken as greater than the keel thickness required by 6.2.

Figure 4.7.1: Rudder horn



4.7.3 See also Part 3 Chapter 9 for more details concerning the rudder horn.

4.8 Skeg construction

4.8.1 Skegs are to be effectively integrated into the adjacent structure and their design is to be such as to facilitate this.

4.9 Forefoot and stem

4.9.1 The thickness of plate stems at the waterline is to comply with the requirements for plate keels as given in 6.2.

4.9.2 The cross-sectional area of bar stems, A, is not to be taken as less than:

$$A = 1{,}5 \cdot L \cdot k_1 \ cm^2$$

where:

L, k_1= as defined in 3.3.1.

SECTION 5 Double bottom structure

5.1 General

5.1.1 The following requirements provide for double bottom construction of steel mono-hull craft in association with either transverse or longitudinal framing.

5.1.2 The double bottom is to be made as wide as possible.

5.1.3 The double bottom is to be fitted extending from the collision bulkhead to the aft peak bulkhead.

5.1.4 If the double bottom is not continuous from the aft peak bulkhead to the collision bulkhead, the margin plate, side girders and center girder must be connected to the longitudinal structure of the single bottom or shall scarf two frame spaces into the single bottom structure.

5.1.5 If the depth of the double bottom does not remain constant, efficient means of transmission of loads within 0,6L amidships are to be provided.

5.2 Keel

5.2.1 The scantlings of bar and plate keels are to comply with the requirements of 4.2.

5.2.2 Duct keels, where arranged, are to have a side plate thickness not less than:

$$t = \sqrt{k_1} \cdot (0{,}01 \cdot d_{DB} + 2)\ mm$$

but need not be taken as greater than 90% of the center girder thickness given in 5.3, d_{DB} is the Rule center girder depth given in 5.3.3 and k_1 as defined in 3.3.1.

5.2.3 Where a duct keel forms the boundary of a tank, the requirements of 9.4 and 9.5 for deep tanks are to be complied with.

5.2.4 The duct keel width is in general to be 15% of the beam or 2 meters, whichever is the lesser, but in no case is it to be taken as less than 630 mm.

5.3 Centre girder

5.3.1 A center girder is to be fitted throughout the length of the craft. The web thickness, t, is not to be less than that the maximum value required by:

$$t = \sqrt{k_1} \cdot (0{,}14 \cdot L + 4)\ mm$$

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{5}{4}L} + 1{,}4\right)\ mm\ or$$

$$5{,}0\ mm$$

-Outside 0,4 · L amidships

$$t = \sqrt{k_1} \cdot (0{,}14 \cdot L + 2{,}75)\ mm$$
$$t = \sqrt{k_2} \cdot \left(0{,}95 \cdot \sqrt{L} + 1{,}4\right)\ mm\ or$$
$$5{,}0\ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

5.3.2 The geometric properties of the girder section are to be in accordance with 3.12.

5.3.3 The overall depth of the center girder, d_{DB}, is to be taken as not less than 630 mm and is to be sufficient to give adequate access to all parts of the double bottom.

5.3.4 Additionally, the requirements of 7.3 for bottom longitudinal primary stiffeners are to be complied with.

5.4 Side girders

5.4.1 Where the floor breadth does not exceed 6,0 m, side girders are not required. Vertical stiffeners are to be fitted to the floors on each side, the number and positions of these stiffeners being dependent on the arrangement of the double bottom structure.

5.4.2 Where the breadth of floor is greater than 6,0 m, additional side girders having the same thickness as the floors are to be fitted. The number of side girders is to be such that the distance between the side girders and center girder and margin plate, or between the side girders themselves, does not exceed 3,0 meters. The web thickness of the side girders is to be taken as not less than the maximum value obtained by:

$$t = \sqrt{k_2} \cdot \left(0{,}8 \cdot \sqrt{L} + 1{,}1\right)\ mm\ or$$
$$4{,}0\ mm$$

where:

L, k_2= as defined in 3.3.1.

5.4.3 Side girders, where fitted, are to extend as far forward and aft as practicable and are in general to terminate in way of bulkheads, deep floors or other primary transverse structure.

5.4.4 Where additional side girders are fitted in way of main machinery seatings, they are to be integrated into the structure of the craft and extended forward and aft as far as practicable.

5.4.5 Under the main engine, girders extending from the bottom shell to the top plate of the engine seating are to be fitted. The height of the giders is to be not less than the height of the floor. Engine holding-down bolts are to be arranged as near as practicable to the girders and floors. Where this cannot be achieved, bracket floors and/or hanging brackets are to be fitted.

5.4.6 Additionally, the requirements of 7.3 for bottom longitudinal primary stiffeners are to be complied with.

5.5 Plate floors

5.5.1 The web thickness of non-watertight plate floors, t, is to be not less than the maximum value obtained by:

$$t = \sqrt{k_1} \cdot (0{,}07 \cdot L + 4{,}75)\ mm$$

$$t = \sqrt{k_2} \cdot \left(0{,}8 \cdot \sqrt{L} + 1{,}1\right)\ mm\ or$$

$$4{,}0\ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

5.5.2 Additionally, the requirements of 7.6 for bottom transverse web frames stiffeners are to be complied with.

5.5.3 Plate floors are, in general, to be continuous between the center girder and the margin plate.

5.5.4 In longitudinally framed craft, plate floors or equivalent structure are in general to be fitted in the following positions:

a) At every half frame in way of the main engines, thrust bearings, and bottom of the craft forward.
b) Outboard of the engine seatings, at every frame within the engine room.
c) Underneath pillars and bulkheads.
d) Outside of the engine room at a spacing not exceeding 2,0 m.

5.5.5 Vertical flat bar stiffeners are to be fitted to all plate floors at each longitudinal. Each stiffener is to have a depth of not less than $10 \cdot t$ and a thickness of not less than t, where t is thickness of the plate floor as calculated in 5.5.1.

5.5.6 In transversely framed craft, plate floors are to be fitted at every frame in the engine room, under bulkheads, in way of change in depth of double bottom and elsewhere at a spacing not exceeding 2,0 m.

5.6 Bracket floors

5.6.1 Between plate floors, the shell and inner bottom plating is to be supported by bracket floors. The brackets are to have the same thickness as plate floors and are to be stiffened on the unsupported edge.

5.6.2 In longitudinally framed craft, the brackets are to extend from the center girder and margin plate to the adjacent longitudinal, but in no case is the breadth of the bracket to be taken as not less than 75% of the depth of the center girder. They are to be fitted at every web frame at the margin plate, and those at the center girder are to be spaced not more than 1,0 m apart.

5.6.3 In transversely framed craft, the breadth of the brackets, attaching the bottom and inner bottom frames to the center girder and margin plate, is to be not less than 75% of the depth of the center girder.

5.7 Additional requirements for watertight floors

5.7.1 The scantlings of watertight floors are to comply with the requirements for plate floors as given in 5.5.

5.8 Tankside brackets

5.8.1 The scantlings of tankside brackets are to comply with the requirements for plate floors given in 5.5.

5.9 Inner bottom plating

5.9.1 The thickness of the inner bottom plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{2} L} + 1{,}3 \right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

5.9.2 Inner bottom plating forming the boundaries of tank spaces is, in addition, to comply with the requirements for watertight bulkheads or deep tanks as detailed in 9.2 or 9.4 respectively. Where the plating forms vehicle, passenger or other decks the requirements of SECTION 8 are to be complied with.

5.9.3 Inner bottom longitudinals are to be supported by inner bottom transverse web frames, floors, bulkheads or other primary structure, generally spaced not more than 2 m apart.

5.9.4 The requirements of section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I, and C_A as detailed in Table 3.14.2 for the load model (a).

5.10 Margin plates

5.10.1 A margin plate, if fitted, is to have a thickness as required for inner bottom plating.

5.11 Manholes

5.11.1 Sufficient manholes are to be cut in the inner bottom, floors and side girders to provide adequate access to, and ventilation of, all parts of the double bottom. The size of the manhole openings is not, in general, to exceed 50% of the double bottom depth unless edge reinforcement is provided.

SECTION 6 Shell envelope plating

6.1 General

5.11.2 The following requirements are applicable to longitudinally and transversely framed shell envelopes.

6.2 Plate keel

6.2.1 The width b and the thickness t of the keel plate are not to be taken as less than the maximum value obtained by:

$$b = 7{,}0 \cdot L + 340 \ mm$$

$$t = 1{,}85 \cdot \sqrt{k_1} \cdot L^{0{,}45} \ mm$$

where:

L, k_1= as defined in 3.3.1.

6.2.2 In no case is the thickness of the keel plate to be less than that of the adjacent bottom shell plating.

6.2.3 The thickness and width of the plate keel are to be maintained throughout the length of the craft from the transom to a point not less than 25% of the freeboard (measured at the forward perpendicular) above the deepest load waterline on the stem. Thereafter the keel thickness may be reduced to that required by 6.3.1 for the stem.

6.2.4 For large or novel craft and for yachts with externally attached ballast keels, the scantlings of the keel will be specially considered.

6.2.5 For bar keels, see 4.2.2.

6.3 Plate stem

6.3.1 The thickness of plate stems, t, is not to be taken as less than:

$$t = \sqrt{k_1} \cdot (0{,}14 \cdot L + 4) \ mm$$

where:

L, k_1= as defined in 3.3.1.

6.3.2 In no case is the thickness of the plate stem to be taken as less than the thickness of the adjacent shell plating.

6.3.3 Plate stems are to be supported by horizontal diaphragms, and where the stem radius is large, a centerline stiffener or web may be required.

6.3.4 For large or novel craft the scantlings of the stem will be specially considered.

6.3.5 The breadth of plate stems is to be not less than the width of keel as required by 6.2.1.

6.4 Bottom shell plating

6.4.1 The thickness of the bottom shell plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{2} L} + 1{,}0 \right) \ mm \ or$$

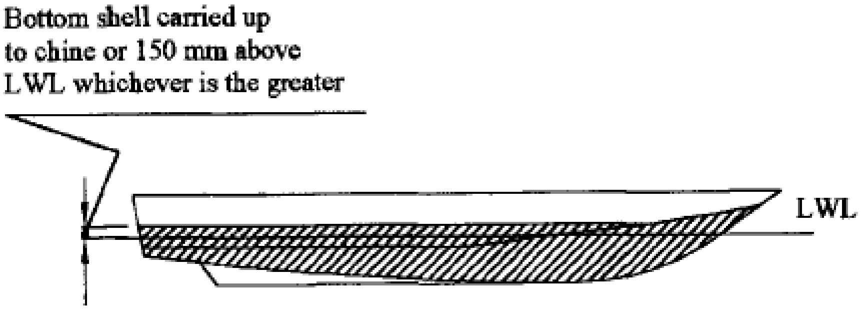
$$4{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

6.4.2 For all craft types the minimum thickness requirement for bottom shell plating is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater see Figure 6.4.1.

Figure 6.4.1: Extent of bottom shell



6.5 Side shell plating

6.5.1 The thickness of the side shell plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{4} L} + 1{,}4 \right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

6.6 Sheerstrake

6.6.1 The sheerstrake is generally to be taken as the side shell, locally reinforced in way of deck/ hull connection and fender attachment. The amount of local reinforcement will be dependent upon the arrangement of structure and the proposed service.

6.6.2 Only the designers/builders are responsible for the fendering arrangements of all craft types.

6.6.3 The above mentioned arrangements are outside the scope of classification.

6.6.4 Fishing crafts are in general to have their shell plating scantling as required to satisfy the Rule loadings, increased by 20%. In addition to this, the side shell is not to be taken less than as bottom shell thickness, and where there are gallows, gantries, nets, or lines etc. the plating in way is to be further increased locally and /or suitably protected by sheathing or other means.

6.6.5 Where a rounded sheerstrake is adopted, the radius, in general, is to be not less than 15 times the thickness.

6.6.6 The sheerstrake thickness is to be increased by 20% at the ends of a bridge superstructure extending out to the craft's side. In case of a bridge superstructure exceeding 0,15·L, the side plating at the ends of the superstructure is also to be increased by 25% and tapered gradually into the upper deck sheerstrake.

6.7 Chines

6.7.1 The chine plate thickness is to be equivalent to the bottom shell thickness required to satisfy the Rule pressure loading, increased by 20%, or 6 mm, whichever is the greater.

6.7.2 Where tube is used in chine construction, the minimum wall thickness is to be not less than the thickness of the bottom shell plating increased by 20%.

6.8 Skegs

6.8.1 The thickness of the skeg plating is to be not less than the thickness of the adjacent bottom shell.

6.9 Transom

6.9.1 The thickness of the stern or transom is to be not less than that required for the side or bottom shell as appropriate.

6.10 Shell openings

6.10.1 Sea-inlets, or other openings, are to have well rounded corners and, so far as is practicable, are to be kept clear of the bilge radius, chine or sheerstrake radius.

6.10.2 Openings on or near the bilge radius may be accepted provided that they are of elliptical shape, or equivalent, to minimise stress concentrations and are, in general, to be cut clear of weld connections.

6.11 Sea inlet boxes

6.11.1 The thickness of the sea inlet box plating is to be 1 mm thicker than the adjacent shell plating, or 8 mm, whichever is the greater.

SECTION 7 Shell envelope framing

7.1 General

7.1.1 The following requirements are applicable to longitudinally and transversely framed shell envelopes.

7.2 Bottom longitudinal stiffeners

7.2.1 Bottom longitudinal stiffeners are to be supported by bottom transverse web frames, floors, bulkheads, or other primary structure, generally spaced not more than 2 meters apart.

7.2.2 Bottom longitudinals are to be continuous through the supporting structures.

7.2.3 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (b).

7.3 Bottom longitudinal primary stiffeners

7.3.1 Bottom longitudinal primary stiffeners are to be supported by bottom deep transverse web frames, floors, bulkheads, or other primary structure, generally spaced not more than 6 metres apart.

7.3.2 Bottom longitudinal primary stiffeners are to be continuous through transverse bulkheads and supporting structures.

7.3.3 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.4 Bottom transverse stiffeners

7.4.1 Bottom transverse stiffeners are defined as local stiffening members which support the bottom shell, and which may be continuous or intercostal.

7.4.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (b).

7.5 Bottom transverse frames

7.5.1 Bottom transverse frames are defined as stiffening members which support the bottom shell. They are to be effectively continuous and bracketed at their end connections to side frames and bottom floors as appropriate.

7.5.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.6 Bottom transverse web frames

7.6.1 Bottom transverse web frames are defined as primary stiffening members which support bottom shell longitudinals. They are to be continuous and substantially bracketed at their end connections to side web frames and bottom floors.

7.6.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.7 Side longitudinals stiffeners

7.7.1 The side longitudinals stiffeners are to be supported by side transverse web frames, bulkheads, or other primary structure, generally spaced not more than 2 meters apart.

7.7.2 Side longitudinals are to be continuous through the supporting structures.

7.7.3 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (b).

7.8 Side longitudinal primary stiffeners

7.8.1 Side longitudinal primary stiffeners are to be supported by side transverse web frames, bulkheads, or other primary structure, generally spaced not more than 6 meters apart.

7.8.2 Side longitudinal primary stiffeners are to be continuous through transverse bulkheads and supporting structures.

7.8.3 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.9 Side transverse stiffeners

7.9.1 Side transverse stiffeners are defined as local stiffening members supporting the side shell and may be continuous or intercostal.

7.9.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (b).

7.10 Side transverse frames

7.10.1 Side transverse frames are defined as stiffening members which support the side shell. They are to be effectively continuous and bracketed at their end connections to bottom floors/frames and deck beams as appropriate.

7.10.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

7.11 Side transverse web frames

7.11.1 Side transverse web frames are defined as primary stiffening members which support side shell longitudinally. They are to be continuous and substantially bracketed at their head and heel connections to deck transverses and bottom web frames respectively.

7.11.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2 for the load model (a).

SECTION 8 Deck structures

8.1 General

8.1.1 The strength deck is:

- The uppermost continuous deck which forms the upper flange of the longitudinal hull girder.
- A superstructure deck which extends up to 0,4L amidships and the length of which exceeds 0,15L. Superstructure decks the length of which is less than 12 m, need not be considered as strength decks.
- A quarter deck or the deck of a superstructure in part below the main deck, which extends through 0,4L amidships.

8.1.2 Deck sectional areas used in the deck area and section modulus calculations are to be maintained throughout the 0,4L amidships. They may be gradually reduced to 50% the normal requirement at 0,15L from the ends.

8.1.3 The geometric properties of stiffener sections are to be in accordance with 3.12.

8.2 Strength/Weather deck plating

8.2.1 The thickness of strength/weather deck plating is to be determined from the general plating equation given in 3.10 using the design pressure head from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{4} L} + 1{,}4 \right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

8.2.2 The scantlings of watertight cockpits are to be of equivalent strength to those of the strength/weather deck.

8.3 Lower deck / Inside deckhouse plating

8.3.1 The thickness of the lower deck/inside deckhouse plating is to be determined from the general plating equation given in 3.10 using the design pressure head from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{9} L} + 1{,}3 \right) \ mm \ or$$

$$3{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

8.4 Accommodation deck plating

8.4.1 Accommodation decks are in general to be treated as lower deck/inside deckhouse decks, with their plating requirements determined in accordance with 8.3.

8.5 Cargo deck plating

8.5.1 The thickness of cargo deck plating is to be determined from the general plating equation given in 3.10 using the design pressure head from Part 3, Chapter 2 of the present Rules.

8.6 Strength / Weather deck stiffening

8.6.1 The Rule requirements for section modulus, inertia and web area for the strength/weather deck primary stiffening are to be determined from the general equations given in 3.11, using the design pressure heads from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a). The minimum thickness for the strength/weather deck primary stiffening is to be determined from the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{4} L} + 1{,}4 \right) \; mm \; or$$

$$3{,}5 \; mm$$

where:

L, k_2= as defined in 3.3.1.

8.6.2 The Rule requirements for section modulus, inertia and web area for the strength / weather deck secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

8.7 Lower deck / Inside deckhouse stiffening

8.7.1 The Rule requirements for section modulus, inertia and web area for lower deck / inside deckhouse stiffening are to be determined from the general equations given in 3.11, using the design pressure head from Part 3,Chapter 2 of the present Rules, and the coefficients C_{SM},C_I and C_A as detailed in Table 3.14.2. Primary members are assumed to be load model (a) and secondary members load model (b).The minimum thickness for lower deck/inside deckhouse stiffening is to be determined from the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{10} L} + 1{,}3 \right) \; mm \; or$$

$$3{,}0 \; mm$$

where:

L, k_2= as defined in 3.3.1.

8.8 Accommodation deck stiffening

8.8.1 Accommodation decks are in general to be treated as lower deck/inside deckhouse decks, with their scantling requirements determined in accordance with 8.7.

8.9 Cargo deck stiffening

8.9.1 The Rule requirements for section modulus, inertia and web area for cargo deck stiffening are to be determined from the general equations given in 3.11, using the design pressure head from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2. Primary members are assumed to be load model (a) and secondary members load model (b).

8.10 Deck openings

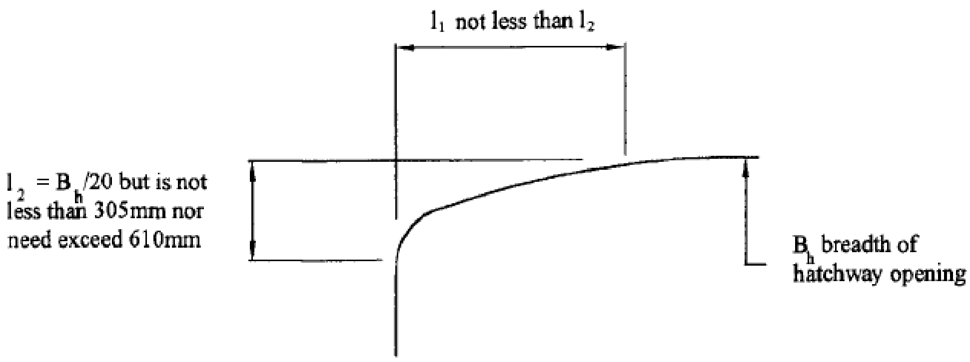
8.10.1 All openings are to be supported by an adequate framing system, pillars or cantilevers. When cantilevers are used scantlings may be derived from direct calculations.

8.10.2 Where stiffening members terminate in way of an opening they are to be attached to carlings, girders, transverses or coaming plates.

8.10.3 The corners of large hatchways in the strength/weather deck within 0,5·L amidships are to be elliptical, parabolic or rounded, with a radius generally not less than 1/24 of the breadth of the opening.

8.10.4 Where elliptical corners are arranged, the major axis is to be fore and aft, the ratio of the major to minor axis is to be not less than two to one nor greater than 2,5 to one, and the minimum half-length of the major axis is to be defined by l_1 in Figure 8.10.1. Where parabolic corners are arranged, the dimensions are also to be shown in Figure 8.10.1.

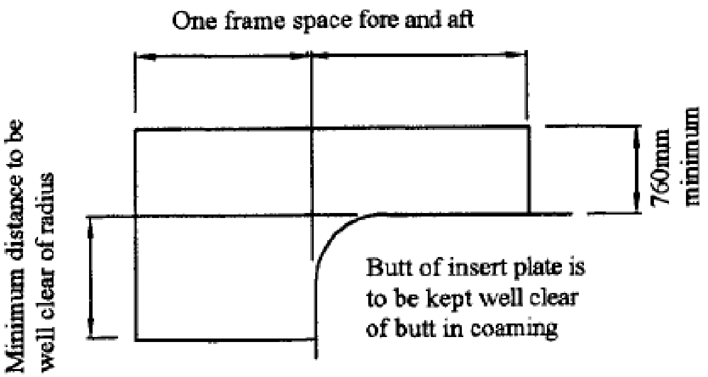
Figure 8.10.1: Hatch opening geometry



8.10.5 Where the corners are parabolic or elliptical, insert plates are not required.

8.10.6 For other shapes of corner, insert plates of the size and extent shown in Figure 8.10.2 will, in general, be required. The required thickness of the insert plate is to be not less than 25% greater than the adjacent deck thickness, outside line of openings.

Figure 8.10.2: Inserts in way of hatch opening



8.10.7 For lower decks the corners of large openings are to be rounded, with a radius generally not less than $^1/_{24}$ of the breadth of the opening.

SECTION 9 Bulkheads

9.1 General

9.1.1 The following requirements apply to bulkheads with both vertical and horizontal framing systems.

9.1.2 Bulkheads, or part bulkheads, forming the boundary of tanks are to comply with the requirements of 9.5 and 9.6.

9.1.3 A centerline bulkhead is, generally, to be fitted in deep tanks which extend from side to side. The bulkhead may be intact or perforated as desired. If intact, the scantlings are to comply with the requirements of 9.5 and 9.6 for tank boundary bulkheads. If swash, they are to comply with the requirements of 9.10 for washplates.

9.2 Watertight bulkhead plating

9.2.1 The thickness of the watertight bulkhead plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{3}{16} L} + 1{,}2 \right) \; mm \; or$$

$$3{,}0 \; mm$$

where:

L, k_2= as defined in 3.3.1.

9.3 Watertight bulkhead stiffening

9.3.1 The Rule requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressure from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 using the appropriate load model.

9.4 Deep tank plating

9.4.1 The thickness of deep tank plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{4} L} + 1{,}4 \right) \; mm \; or$$

$$3{,}5 \; mm$$

where:

L, k_2= as defined in 3.3.1.

9.5 Deep tank stiffening

9.5.1 Deep tank bulkhead stiffeners are to be bracketed at both ends. The thickness of the brackets is to be not less than the web thickness of the stiffener.

9.5.2 The Rule requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressure from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for load model (b).

9.6 Double bottom tanks

9.6.1 The scantlings of double bottom tanks are to comply with the requirements for deep tanks given in 9.4 and 9.5.

9.6.2 Where the bulkhead deck/ tank top of a double bottom tank forms a vehicle, passenger or other deck, the requirements of SECTION 8 are to be complied with.

9.7 Collision bulkheads

9.7.1 The scantlings of collision bulkheads are to be not less than as required for deep tank bulkheads contained in 9.4 and 9.5.

9.8 Non-watertight or partial bulkheads

9.8.1 Where a bulkhead is structural but non-watertight the scantlings are in general to be as for watertight bulkheads. Partial bulkheads that are non-structural are outside the scope of classification.

9.9 Corrugated bulkheads

9.9.1 The plating thickness and section modulus for symmetrical corrugated bulkheads are to be in accordance with watertight bulkheads or deep tank bulkheads as appropriate.

9.10 Wash plates

9.10.1 Tanks are to be subdivided as necessary by internal baffles or wash plates. Baffles or wash plates which support hull framing are to have scantlings equivalent to web frames in the same position.

9.10.2 Wash plates and wash bulkheads are, in general, to have an area of perforation not less than 10% of the total area of the bulkhead. The perforations are to be so arranged that the efficiency of the bulkhead as a support is not impaired.

9.10.3 The plate thickness is to be not less than the structural element from which the wash bulkhead is formed.

9.10.4 The general stiffener requirements are to be in accordance with 9.5. However, the section modulus may be 50% of that required by 9.5.

SECTION 10 Superstructures and deckhouses

10.1 Superstructure and deckhouse side plating

10.1.1 The thickness of house side plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{6}L} + 1{,}1 \right) \; mm \; or$$

$$3{,}0 \; mm$$

where:

L, k_2= as defined in 3.3.1.

10.2 Superstructure and deckhouse front plating

10.2.1 The thickness of the house front plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the below equations:

a) Superstructure and deckhouse front 1st tier plating:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{5}{13} L} + 1{,}8 \right) \ mm \ or$$

$$3{,}5 \ mm$$

b) Superstructure and deckhouse front upper tiers plating:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{3}{10} L} + 1{,}5 \right) \ mm \ or$$

$$3{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

10.3 Superstructure and deckhouse end plating

10.3.1 The thickness of the house end plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the below equations:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{16} L} + 1{,}7 \right) \ mm \ or$$

$$2{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

10.4 Superstructure and deckhouse top plating

10.4.1 The thickness of the house top plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules.

10.5 Coachroof plating

10.5.1 The thickness of the coachroof plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules.

10.6 Machinery casing plating

10.6.1 The thickness of the plating of machinery casings is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules.

10.7 Forecastle requirements

10.7.1 The forecastle side plating may be a continuation of the hull side shell plating or fitted as a separate assembly. In both cases the plating thickness is to be the same as the side shell plating at deck edge. Where fitted as a separate assembly, suitable arrangements are to be made to ensure continuity of the effect of the sheerstrake at the break and at the upper edge of the forecastle side. Full penetration welding is to be used.

10.7.2 The side plating is to be stiffened by side frames effectively connected to the deck structure. Deep webs are to be fitted to ensure overall rigidity.

10.7.3 The deck plating thickness is to be increased by 20% in way of the end of the forecastle if this occurs at a position aft of $0{,}25 \cdot L$ from the F.P. No increase is required if the forecastle end bulkhead lies forward of $0{,}2 \cdot L$ from the F.P. The increase at intermediate positions of end bulkhead is to be obtained by interpolation.

10.8 Superstructure and deckhouse side stiffeners

10.8.1 The Rule requirements for section modulus, inertia and web area for the house side primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.9 Superstructure and deckhouse front stiffeners

10.9.1 The Rule requirements for section modulus, inertia and web area for house front primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.9.2 The Rule requirements for section modulus, inertia and web area for house front secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.10 Superstructure and deckhouse aft end stiffeners

10.10.1 The Rule requirements for section modulus, inertia and web area for house aft end primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.10.2 The Rule requirements for section modulus, inertia and web area for house aft end secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.11 Superstructure and deckhouse top stiffeners

10.11.1 The superstructure and deckhouse top is to be effectively supported by a system of transverse or longitudinal beams and girders. The span of the beams is in general not to exceed 2,4 meters and the beams are to be effectively connected to the house upper coamings and girders.

10.11.2 The Rule requirements for section modulus, inertia and web area for house top primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.11.3 The Rule requirements for section modulus, inertia and web area for house top secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.12 Coachroof stiffeners

10.12.1 The Rule requirements for section modulus, inertia and web area for coachroof primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.12.2 The Rule requirements for section modulus, inertia and web area for coachroof secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.13 Machinery casing stiffeners

10.13.1 The Rule requirements for section modulus, inertia and web area for machinery casing primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

10.13.2 The Rule requirements for section modulus, inertia and web area for machinery casing secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

10.14 Forecastle stiffeners

10.14.1 The scantlings of forecastle primary and secondary stiffening members are to be equivalent to those for the side shell envelope framing at the deck edge as required by SECTION 7.

10.15 Superstructures formed by extending side structures

10.15.1 Superstructure first tier sides formed by extending the hull side structure are to be in accordance with the requirements for house fronts given in 10.2 and 10.11 for plating and stiffeners respectively, but need not be taken as greater than the side structure requirements at the deck edge at the same longitudinal position.

10.16 Bulwarks

10.16.1 The thickness of the bulwark plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules.

10.16.2 The requirements for section modulus, inertia and web area for machinery casing primary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (d).

10.16.3 Fishing craft are to have bulwarks fitted. The bulwark may be formed from a continuation of the side shell plating or connected as a separate assembly. Where the bulwark is considered to be stressed and contributing to the global strength of the craft, the plate thickness of the bulwark is not to be less than the sheerstrake plating thickness. In no case is the thickness of the bulwark plating to be taken as less than 80% of the side shell thickness. The bulwark is to be supported by suitable stiffening members which may be formed from a continuation of the side frames, or from flanged plate stays of the same thickness as the bulwark. In general these frames are to be spaced not more than two side frame spacings apart.

SECTION 11 Structural scantlings for multi-hull vessels-General principles and requirements

11.1 Application

11.1.1 The requirements of this section are applicable to multi-hull craft of aluminum construction.

11.2 Direct calculations

11.2.1 In case the design, form or proportions of the craft are unusual, or the speed of the craft exceeds 60 knots, the scantlings are to be determined by direct calculation.

11.2.2 In any case direct calculations based on well-established principles of mechanics may be used alternatively or complementary to these Rules, provided that the achieved level of safety remains equivalent.

11.3 Symbols and definitions

11.3.1 The symbols used in this Section are defined below:

L= Rule length of craft, in metres,

s= stiffener spacing, in mm

k_1, k_2= material factors as defined in Table 3.4.2,

t= plating thickness, in mm

11.3.2 Bottom outboard. For high speed craft, where the scantlings of the bottom shell are governed by impact pressure considerations, the bottom outboard shell is defined as the area of the hull between the outboard edge of the keel and the outer bilge tangential point. For displacement and semi displacement type craft where the scantlings of the bottom shell are governed by either hydrostatic or pitching pressures the bottom outboard shell is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

11.3.3 Bottom inboard. For high speed craft, where the scantlings of the bottom shell are governed by impact pressure considerations, the bottom inboard shell is defined as the area of the hull between the inboard edge of the keel and the inner bilge tangential point. For displacement and semi displacement type craft where the scantlings of the bottom shell are governed by either hydrostatic or pitching pressures the bottom inboard shell is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

11.3.4 Haunch. The haunch is defined as the transition area between the cross-deck and the inboard side shell plating.

11.3.5 Cross-deck. The cross-deck is defined as the structure which forms the bridge connection between any two adjacent hulls.

11.3.6 Side inboard. The side inboard is defined as the area between the bottom inboard shell and the wet-deck (or lower edge of the haunches, where fitted).

11.3.7 Side outboard. The side outboard is defined as the area between bottom outboard shell and the deck at side.

11.3.8 Wet-deck. The wet-deck is defined as the area between the upper edges of the side inboard plating (or upper edges of the haunches, where fitted).

SECTION 12 Single bottom structure and appendages

12.1 Keel

12.1.1 The scantlings and arrangements of plate keels are to be in accordance with 14.1.

12.1.2 Where fitted, the cross-sectional area, A, and thickness, t, of bar keels should not, in general, be taken as less than:

$$A = k_1 \cdot (1{,}85 \cdot L + 2{,}0)\ cm^2$$
$$t = \sqrt{k_1} \cdot (0{,}7 \cdot L + 8{,}25)\ mm$$

where:

L, k_1= as defined in 3.3.1.

12.2 Centre girder

12.2.1 Centerline girders are to be fitted throughout the length of each hull and are generally to be fitted in association with transverse frames, transverses supporting longitudinals or where the breadth of floors at the upper edge is greater than 1,5 m.

12.2.2 The web depth of the center girder is, in general, to be equal to the depth of the floors at the centerline as specified in 12.4.3.

12.2.3 The web thickness, t, of the center girder is to be taken as not less than the maximum value obtained by the below equations:

$$t = \sqrt{k_1} \cdot \left(\sqrt{1{,}90 \cdot L} + 1{,}3\right)\ mm\ or$$
$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{5}{4}L} + 1{,}4\right)\ mm\ or$$

$$5{,}0\ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

12.2.4 The face flat area, A, of the center girder is to be not less than:

$$A = 0{,}42 \cdot L \cdot k_1\ cm^2$$

where:

L, k_1= as defined in 3.3.1.

12.2.5 The face flat area of the center girder outside 0,5 · L may be 80% of the value given in 12.2.4.

12.2.6 The face flat thickness, t, is to be not less than the thickness of the web.

12.2.7 The ratio of the width to thickness of the face flat is to be not less than eight but is not to exceed sixteen.

12.2.8 Additionally, the requirements of 15.8 for bottom inboard longitudinal primary stiffeners are to be complied with.

12.3 Side girders

12.3.1 Where the floor breadth at the upper edge exceeds 4,0 m side girders are to be fitted at each side of the center girder such that the spacing between the side and center girders or between the side girders themselves is not greater than 2 meters.

12.3.2 The web thickness, t, of side girder is to be taken as not less than the maximum value obtained by the below equations:

$$t = \sqrt{0{,}85 \cdot L \cdot k_1} \ \ mm\ or$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14}L} + 1{,}1\right) \ mm\ or$$

$$4{,}0\ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

12.3.3 The face flat area and thickness of side girders are to comply with the requirements for plate floors as defined in 12.4.5 and 12.4.6.

12.3.4 Additionally, the requirements of 15.8 for bottom inboard longitudinal primary stiffeners are to be complied with.

12.4 Floors general

12.4.1 In transversely framed craft, floors are generally to be fitted at every frame and underneath each bulkhead.

12.4.2 In longitudinally framed craft, floors are, in general, to be fitted at every transverse web frame and bulkhead and generally at a spacing not exceeding 2 meters.

12.4.3 The overall web depth, d, of floors at the centerline, is not to be taken as less than:

$$d = 6{,}2 \cdot L + 50 \ mm$$

where:

L= as defined in 3.3.1.

12.4.4 The web thickness of plate floors, t, is to be not less than the maximum value obtained by the below equations:

$$t = \sqrt{k_1} \cdot (0{,}0047 \cdot d + 3{,}1) \cdot (0{,}001 \cdot s + 0{,}5) \quad mm\ or$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14}L + 1{,}1}\right) \quad mm\ or$$

$$4{,}0\ mm$$

where:

d= determined from 12.4.3

L, k_1, k_2, s = as defined in 3.3.1.

12.4.5 The face flat area, A, of floors is not to be taken as less than:

$$A = 0{,}21 \cdot L \cdot k_1 \ cm^2$$

where:

L, k_1= as defined in 3.3.1.

12.4.6 The face flat thickness, t, is to be not less than the thickness of the web and the ratio of the web to the thickness of the face flat is to be not less than eight but is not to exceed sixteen.

12.4.7 Additionally, the requirements of 15.6 for bottom outboard transverse web frames are to be complied with.

12.5 Floors in machinery spaces

12.5.1 The web thickness, t, of floors in machinery spaces is to be 1 mm greater than that required by 12.4.4.

12.6 Forefoot and stem

12.6.1 The thickness of plate stems at the waterline is to comply with the requirements for plate keels as given in 14.1.

12.6.2 The cross-sectional area of bar stems, A, is not to be taken as less than:

$$A = 1{,}1 \cdot L \cdot k_1 \ cm^2$$

where:

L, k_1= as defined in 3.3.1.

SECTION 13 Double bottom structure

13.1 Keel

13.1.1 The scantlings of plate and bar keels are to comply with the requirements of 12.1.

13.2 Centre girder

13.2.1 A center girder is to be fitted throughout the length of the craft. The web thickness, t, is to be not less than the maximum value obtained by the below equations for each region:

- Within 0,4 · L amidships

$$t = \sqrt{k_1} \cdot (0{,}082 \cdot L + 4{,}1)\ mm\ or$$

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{6}{5}L} + 1{,}4\right)\ mm\ or$$

$$5{,}0\ mm$$

- At ends

$$t = \sqrt{k_1} \cdot (0{,}082 \cdot L + 2{,}7)\ mm\ or$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{10}L} + 1{,}4\right)\ mm\ or$$

$$5{,}0\ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

13.2.2 The overall web depth, d, of the center girder is to be taken as not less than 630 mm and is to be sufficient to give adequate access to all parts of the double bottom.

13.2.3 Additionally, the requirements of 15.8 for bottom inboard longitudinal primary stiffeners are to be complied with.

13.3 Side girders

13.3.1 The thickness of the side girder plating is not to be taken as less than the maximum of the following values:

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14}L} + 1{,}1\right)\ mm\ or$$

$$4{,}0\ mm$$

where:

L, k_2= as defined in 3.3.1.

13.3.2 Where the floor breadth does not exceed 4,0 m, side girders are not required. Vertical stiffeners are to be fitted to the floors on each side, the number and positions of these stiffeners being dependent on the arrangement of the double bottom structure.

13.3.3 Where the breadth of floor is greater than 4,0 m, additional side girders having the same thickness as the floors are to be fitted. The number of side girders is to be such that the distance between the side girders and center girder and margin plate, or between the side girders themselves, does not exceed 2,0 meters.

13.4 Plate floors

13.4.1 The web thickness, t, of non-watertight plate floor is to be not less than the maximum of the following values:

$$t = \sqrt{k_1} \cdot (0{,}41 \cdot L + 4{,}8)\ mm\ or$$

$$t = \sqrt{k_2} \cdot \left(3 \cdot \sqrt{\frac{1}{14}L + 1{,}1}\right)\ mm\ or$$

$$4{,}0\ mm$$

where:

L, k_1, k_2= as defined in 3.3.1.

13.4.2 Additionally, the requirements of 15.6 for bottom outboard transverse web frames are to be complied with.

13.4.3 Plate floors are, in general, to be continuous between the center girder and the margin plate.

13.4.4 In longitudinally framed craft, plate floors are to be fitted in the following positions:

- At every half frame in way of the main engines, thrust bearings, and bottom of the craft forward.
- Outboard of the engine seatings, at every frame within the engine room.
- Underneath pillars and bulkheads.
- Outside of the engine room at a spacing not exceeding 2,0 m.

13.4.5 Vertical flat bar stiffeners are to be fitted to all plate floors at each longitudinal. Each stiffener is to have a depth of not less than $10 \cdot t$ and a thickness of not less than t, where t is the thickness of the plate floor as calculated in 13.4.1.

13.4.6 In transversely framed craft, plate floors are to be fitted at every frame in the engine room, under bulkheads, in way of change in depth of double bottom and elsewhere at a spacing not exceeding 2,0 m.

SECTION 14 Shell envelope plating

14.1 Keel plates

14.1.1 The breadth, b, and thickness, t, of plate keels are not to be taken as less than:

$$b = 5{,}0 \cdot L + 250 \ mm$$
$$t = 1{,}85 \cdot \sqrt{k_1} \cdot L^{0{,}45} \ mm$$

where:

L, k_1= as defined in 3.3.1.

14.1.2 In no case is the thickness of the keel to be less than that of the adjacent bottom shell plating.

14.2 Bottom outboard

14.2.1 The thickness of the bottom outboard plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{2} L} + 1{,}0 \right) \ mm \ or$$
$$4{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.2.2 For all craft types, the minimum bottom outboard shell thickness requirement given in 14.2.1 is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

14.3 Bottom inboard

14.3.1 The thickness of the bottom inboard plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3,Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{2} L} + 1{,}0 \right) \ mm \ or$$
$$4{,}0 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.3.2 For all craft types, the minimum bottom inboard shell thickness requirement given in 7.4 is to extend to the chine line or 150 mm above the static load waterline, whichever is the greater.

14.4 Side outboard

14.4.1 The thickness of the side outboard plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{4} L} + 1{,}4 \right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.5 Side inboard

14.5.1 The thickness of the side inboard plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{4} L} + 1{,}4 \right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.6 Wet-deck

14.6.1 The thickness of the wet-deck plating is to be determined from the general plating equation given in 3.10 using the design pressure from Part 3, Chapter 2 of the present Rules, and not to be less than the maximum value obtained by the following formulas:

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{4} L} + 1{,}4 \right) \ mm \ or$$

$$3{,}5 \ mm$$

where:

L, k_2= as defined in 3.3.1.

14.6.2 Additionally, the thickness of the wet-deck plating is in no case to be less than the thickness of the side inboard shell plating determined from 14.5.

14.7 Transom

14.7.1 The scantlings and arrangements of the stern or transom are to be not less than that required for the adjacent bottom inboard or side outboard structure as appropriate.

SECTION 15 Shell envelope framing

15.1 General

15.1.1 The following requirements apply to longitudinally and transversely framed shell envelopes.

15.2 Bottom outboard longitudinal stiffeners

15.2.1 Bottom outboard longitudinal stiffeners are to be supported by transverse web frames, floors, bulkheads, or other primary structure, generally spaced not more than 2 meters apart.

15.2.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.3 Bottom outboard longitudinal primary stiffeners

15.3.1 Bottom outboard longitudinal primary stiffeners are to be supported by deep transverse web frames, floors, bulkheads, or other primary structure, generally spaced not more than 4 meters apart.

15.3.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.4 Bottom outboard transverse stiffeners

15.4.1 Bottom outboard transverse stiffeners are defined as local stiffening members which support the bottom shell.

15.4.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.5 Bottom outboard transverse frames

15.5.1 Bottom outboard transverse frames are defined as stiffening members which support the bottom shell.

15.5.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.6 Bottom outboard transverse web frames

15.6.1 Bottom outboard transverse web frames are defined as primary stiffening members which support bottom shell longitudinals.

15.6.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3,Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.7 Bottom inboard longitudinal stiffeners

15.7.1 The scantlings and arrangements for bottom inboard longitudinal stiffeners are to be determined in accordance with the procedures described in 15.2 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.8 Bottom inboard longitudinal primary stiffeners

15.8.1 The scantlings and arrangements for bottom inboard longitudinal primary stiffeners are to be determined in accordance with the procedures described in 15.3 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.9 Bottom inboard transverse stiffeners

15.9.1 The scantlings and arrangements for bottom inboard transverse stiffeners are to be determined in accordance with the procedures described in 15.4 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.10 Bottom inboard transverse frames

15.10.1 The scantlings and arrangements for bottom inboard transverse frames are to be determined in accordance with the procedures described in 15.5 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.11 Bottom inboard transverse web frames

15.11.1 The scantlings and arrangements for bottom inboard transverse web frames are to be determined in accordance with the procedures described in 15.6 using the bottom inboard stiffening member design pressure from Part 3, Chapter 2 of the present Rules.

15.12 Side outboard longitudinal stiffeners

15.12.1 The side outboard longitudinal stiffeners are to be supported by transverse web frames, bulkheads, or other primary structure, generally spaced not more than 2 meters apart.

15.12.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.13 Side outboard longitudinal primary stiffeners

15.13.1 Side outboard longitudinal primary stiffeners are to be supported by side transverse web frames, bulkheads, or other primary structure, generally spaced not more than 4 meters apart.

15.13.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.14 Side outboard transverse stiffeners

15.14.1 Side outboard transverse stiffeners are defined as local stiffening members supporting the side shell.

15.14.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.15 Side outboard transverse frames

15.15.1 Side outboard transverse frames are defined as stiffening members which support the side shell.

15.15.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.16 Side outboard transverse web frames

15.16.1 Side outboard transverse web frames are defined as primary stiffening members which support side shell longitudinals.

15.16.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.17 Side inboard longitudinal stiffeners

15.17.1 The scantlings and arrangements for side inboard longitudinal stiffeners are to be determined in accordance with the procedures described in 15.12 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.18 Side inboard longitudinal primary stiffeners

15.18.1 The scantlings and arrangements for side inboard longitudinal primary stiffeners are to be determined in accordance with the procedures described in 15.13 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.19 Side inboard transverse stiffeners

15.19.1 The scantlings and arrangements for side inboard transverse stiffeners are to be determined in accordance with the procedures described in 15.14 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.20 Side inboard transverse frames

15.20.1 The scantlings and arrangements for side inboard transverse stiffeners are to be determined in accordance with the procedures described in 15.16 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.21 Side inboard transverse web frames

15.21.1 The scantlings and arrangements for side inboard transverse stiffeners are to be determined in accordance with the procedures described in 15.15 using the side inboard design pressure from Part 3, Chapter 2 of the present Rules.

15.22 Wet-deck longitudinal stiffeners

15.22.1 The wet-deck longitudinal stiffeners are to be supported by transverse web frames, bulkheads, or other primary structure, generally spaced not more than 2 meters apart.

15.22.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.22.3 In no case are the scantlings and arrangements for the wet-deck longitudinal stiffeners to be taken as less than those required for the side inboard longitudinal stiffeners detailed in 15.17.

15.23 Wet-deck longitudinal primary stiffeners

15.23.1 Wet-deck longitudinal primary stiffeners are to be supported by transverse web frames, bulkheads, or other primary structure, generally spaced no more than 4 meters apart.

15.23.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.23.3 In no case are the scantlings and arrangements for the wet-deck longitudinal primary stiffeners to be taken as less than those required for the side inboard longitudinal primary stiffeners detailed in 15.18.

15.24 Wet-deck transverse stiffeners

15.24.1 Wet-deck transverse stiffeners are defined as local stiffening members supporting the wet-deck.

15.24.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (b).

15.24.3 In no case are the scantlings and arrangements for the wet-deck transverse stiffeners to be taken as less than those required for the side inboard transverse stiffeners detailed in 15.19.

15.25 Wet-deck transverse frames

15.25.1 Wet-deck transverse frames are defined as stiffening members which support the wet-deck.

15.25.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.25.3 In no case are the scantlings and arrangements for the wet-deck transverse frames to be taken as less than those required for the side inboard transverse frames detailed in 15.20.

15.26 Wet-deck transverse web frames

15.26.1 Wet-deck transverse web frames are defined as primary stiffening members which support wet-deck longitudinals.

15.26.2 The requirements for section modulus, inertia and web area are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

15.26.3 In no case are the scantlings and arrangements for the wet-deck transverse web frames to be taken as less than those required for the side inboard transverse web frames detailed in 15.21.

SECTION 16 Deck structures

16.1 Cross-deck plating

16.1.1 The thickness of the cross-deck plating is to be determined from the general plating equation given in 3.10, using the design pressure from Part 3, Chapter 2 of the present Rules.

16.1.2 The thickness of the cross-deck plating is in no case to be less than the appropriate minimum requirements given below:

a) Strength/Main deck plating

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{4} L} + 1{,}4 \right) \; mm \; or$$

$$3{,}5 \; mm$$

b) Lower deck/Inside deckhouse plating

$$t = \sqrt{k_2} \cdot \left(\sqrt{\frac{1}{11} L} + 1{,}3 \right) \; mm \; or$$

$$3{,}0 \; mm$$

where:

L, k_2= as defined in 3.3.1.

16.2 Cross-deck stiffening

16.2.1 The Rule requirements for section modulus, inertia and web area for the cross-deck primary stiffeners are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

16.2.2 The Rule requirements for section modulus, inertia and web area of the strength / weather deck secondary stiffening are to be determined from the general equations given in 3.11, using the design pressures from Part 3, Chapter 2 of the present Rules, and the coefficients C_{SM}, C_I and C_A as detailed in Table 3.14.2 for the load model (a).

SECTION 17 Bulkheads and deep tanks

17.1 Longitudinal bulkheads within the cross-deck structure

17.1.1 The scantlings and arrangements for cross deck longitudinal bulkheads are to be determined in accordance with the procedures described in 9.2 and 9.3 for bulkheads in mono-hull craft.

17.2 Transverse bulkheads within the cross-deck structure

17.1.2 The scantlings of cross deck transverse bulkheads are to be determined in accordance with the procedures described in 9.2 and 9.3 for bulkheads in mono-hull craft.

SECTION 18 Superstructures, deckhouses and bulwarks

18.1 General

18.1.1 The scantlings and arrangements for superstructures, deckhouses and bulwarks are to be determined in accordance with the procedures described in SECTION 10 for mono-hull craft.

CHAPTER 7 HULL CONSTRUCTION - WOOD

SECTION 1 Structural scantlings of vessels with round bottom

1.1 General

1.1.1 The scantling in this section apply generally to hulls of length not exceeding 36 meters with round bottom of shape and fitted with fixed ballast or drop keel. Vessels of length exceeding 36 meters or hull shaped other than the above will be considered in case on the basis of equivalence criteria.

1.2 Keel

1.2.1 The scantlings of wooden keels are given in Table 1.3.1. The keel thickness is to be maintained throughout the length, while the width may be gradually tapered at the ends so as to be faired to the stem and the sternpost. The breadth of the rabbet on the keel for the first plating strake is to be at least twice the thickness and not less than 25 mm.

1.2.2 When the length, L, does not exceed 12 m the wood keel is to be in one length. In larger craft the keel should, where is possible, be in one length but when a scarph is necessary in the centerline structure is to have a length, l, not less than 6 times the moulding, m, of the item. The scarph is to be of the hookes or tabled type if bolted or plain type without lips id glued. The depth of the lips is to be about 1/4 to 1/7 of the moulding.

1.2.3 Where the keel is cut for the passage of a drop keel width is to be increased.

1.2.4 Where the mast is stepped on the keel it is be arranged aft of the forward end of the ballast keel. Where this is not practicable effective longitudinal stiffeners are to be arranged extending well forward and of the mast step and effectively connected to the keel.

1.2.5 Bolted scarfs are to be made watertight by means of softwood stopwaters.

1.2.6 The scantlings of wooden keels are given in Table 1.3.1.

1.3 Stempost and sternpost

1.3.1 The stempost shall be adequately scarfed to the keel and increased in width at the heel as necessary so as to fit the keel fairing.

1.3.2 Stempost and sternpost scantlings are given in Table 1.3.1.

1.3.3 The lower portion of the sternpost shall be tenoned or otherwise attached to the keel. The connection is completed by a stern deadwood and a large bracket fastening together false keel, keel and post by means of through bolts.

1.3.4 The counter stern shall be effectively connected to the sternpost. Where practicable such connection shall be effected by scarfs with through bolts. The section area of the counter stern at the connection with the sternpost shall be not less than that of the latter. Such area may be reduced at the upper end by 25%.

Table 1.3.1: Keel, Stempost, Sternpost

Length of the vessel	Keel		Stempost				Sternpost	
L	width	depth	at heel		at head		width	depth
m	mm	mm	width mm	depth mm	width mm	depth mm	mm	mm
10	220	110	120	120	100	100	100	100
12	255	125	140	140	115	115	115	115
14	285	140	155	155	125	125	125	125
16	320	160	170	170	140	140	140	140
18	355	175	190	190	150	150	150	150
20	385	195	205	205	165	165	165	165
22	410	210	220	220	175	175	175	175
24	435	230	240	240	190	190	190	190
26	455	245	255	255	200	200	200	200
28	470	260	270	270	215	215	215	215
30	480	280	290	290	230	230	230	230
32	490	300	310	310	245	245	245	245
34	495	315	325	325	255	255	255	255
36	500	330	340	340	270	270	270	270

1.4 Frames

1.4.1 Bent frames consist of steam warped listels. Their width and thickness are to be uniform over the whole length. The frames are to be in one piece from keel to gunwale and where practicable from gunwale to gunwale running continuous above the keel.

1.4.2 Grown frames consist of naturally curved timbers connected by means of scarfs or butted and strapped. Their width is to be uniform while their depth is to gradually tapered from heel to head. The length of scarfs is to be not less than 6 times the width and they are to be glued.

1.4.3 Laminated frames consist of glued wooden layers. The glued may take place before forming where the latter is slight. Otherwise it should be carried out in loco or be prefabricated by means of suitable strong moulds.

1.4.4 Steel (Metal) frames consist of angles properly curved and bevelled such that the flange to planking is closely fayed to the same planking.

1.4.5 Framing systems and scantlings

a) The admissible framing systems and the frame scantlings are indicated in Table 1.4.1. The following framing systems are taken into consideration:

Type I : all equal frames of the bent type,

Type II : all equal frames of grown laminated or steel angle type,

Type III: frames of scantlings as required for Type II but with one two or three bent frames.

These types are hereafter referred to respectively as Type III_1, Type III_2, Type III_3.

When a frame spacing other than that specified in the table is adopted, the section modulus of the frame is to be modified proportionally. For wooden rectangular sections, a being the width and b the height of the Rules section for the spacing s, a_1 and b_1 the actual values for the assumed spacing s_1, it follows that:

$$\alpha_1 \cdot b_1{}^2 \geq a \cdot b^2 \cdot \frac{s_1}{s}$$

b) The width of frames is to be not less than that necessary for the fastening. Their depth is in any case to be assumed as not less than 2/3 of the width, except where increased width is required for local strengthening in way of masts. The table scantlings duly modified where necessary for the specific gravity of the timber and for the frame spacing are to be maintained for 0.6 of the hull length amidships. Outside the said zone the following reductions may be applied:

- for bent or laminated frames: 10% in width,
- for grown frames: 20% in width throughout the length of the frame and 20% in depth of the head, metal frames: 10% in thickness.

c) Frames are to be properly shaped so as to fit the planking perfectly. Where no floors are arranged the frames are to be wedged into and fastened at the heels of the centerline structural member If the hull. When internal ballast supported by the frames is arranged the latter are to be increased in scantlings.

d) Frames adjacent to masts are to be strengthened on each side as follows or equivalent arrangements are to be provided:

- Type I framing:

Three grown frames are to be fitted with scantlings as required for Type II framing but with constant depth equal to that indicated in Table 1.4.1 for the heel. Such frames are to be arranged instead of alternate bent frames. Otherwise six consecutive bent frames with a cross section increased by 60% in respect of that shown in the above mentioned table may be fitted.

- Type II framing

Three grown frames are to be fitted with a cross section increased by 50% in respect of that required for the heel in the above mentioned table and constant depth. Such frames are to be alternated with ordinary grown frames. If alternate frames are adopted they are to be stiffened by reverse frames of scantlings as prescribed for the reverse frames of plate floors.

- Type III framing

Three grown frames with a cross section increased by 50% in respect of that required for the heel in the above mentioned table and constant depth are to be arranged at Rules spacing with one or two intermediate bent frames. If steel frames are adopted three are to be stiffened by reverse frames with scantlings as required for the frames of plate floors and arranged with one or two intermediate bent frames.

When on way of the mast a sufficiently strong bulkhead is provided such increased frames may be reduced in number to two.

Table 1.4.1: Frames

Depth of the vessel	TYPE I Bent frames only			TYPE II Grown or laminated or steel frames only						
					Grown frames			Laminated frames		Steel frames
D	spacing	width	depth	spacing	width	depth mm		width	depth	Section modulus
m	mm	mm	mm	mm	mm	at heel	at head	mm	mm	cm^3
1.6	145	19	15	185	18	23	18	20	20	0.7
1.8	155	24	19	200	24	30	24	24	24	0.7
2	165	30	23	220	30	37	28	28	28	0.8
2.2	175	35	27	237	36	44	33	31	31	1
2.4	185	41	30	255	43	50	37	35	37	1.2
2.6	195	46	34	270	48	57	42	38	40	1.7
2.8	205	51	37	288	55	65	47	42	46	2.3
3	215	57	40	305	61	74	53	47	52	3.1
3.2	225	62	43	322	68	83	58	50	59	4.4
3.4	235	67	46	340	75	91	68	54	66	6
3.6	245	72	49	355	81	100	80	59	74	7.9
3.8	255	77	52	375	87	112	92	63	84	10.2
4	265	82	55	390	94	124	100	67	94	12.5
4.2	-	-	-	408	100	140	117	73	102	14.5

Depth of the vessel	TYPE III Grown or laminated or steel frames alternated with bent frames				
D	Spacing between frames and intermediate ones			Bent frames	
m	1 bent frames	2 bent frames	3 bent frames	length	depth
	mm	mm	mm	mm	mm
1.6	330	440	520	20	18
1.8	365	470	545	25	20
2	390	500	570	29	22
2.2	410	520	590	33	24
2.4	440	540	620	37	28
2.6	460	570	640	39	29
2.8	490	590	670	41	31
3	515	620	695	43	33
3.2	560	650	730	45	35
3.4	590	690	770	48	39
3.6	620	725	800	50	43
3.8	650	765	840	53	47
4	380	800	870	546	51
4.2	-	-	-	-	-

1.5 Floors

1.5.1 Floors may be made of wood or metal (steel or aluminum). The type of floors to be fitted is dependent on the frame type adopted as follows:

a) Wooden floors as a rule may only be employed in association with grown frames and are to be flanked by them.

b) Metal floors are employed in association with either bent grown or laminated frames and are arranged on the internal profile of the frames.

c) Angle floors may be employed with either bent grown or laminated frames and may be arranged as show in Table 1.5.1.

d) When they are arranged with a flange inside an angle lug is to be fitted in way of the throat for the connection to the wooden keel.

e) Plate floors may be employed in association with either grown or angle frames. The internal edge is to be provided with a reverse angle or a flange, in the latter case the thickness is to be increased by 10%.

1.5.2 Where type I framing with bent frames is adopted floors are to be fitted inside amidships as 0.6L follows:

a) on every second frame of the hull depth does not exceed 2.75 meters and on every frame in hulls of greater depth.

b) on every second frame inside 0.6L amidships and outside such area over an extent corresponding to the length on the waterline.

c) on every third frame elsewhere.

1.5.3 Where type III framing is adopted a floor is to be fitted in way of every grown laminated or angle frame. Where one or two intermediate bent frames are to be arranged and the depth D exceeds 2.4 m floors are to be fitted on bent frames located inside 0.6 L amidships. Where three intermediate bent frames are arranged floor is to be fitted on the central one.

1.5.4 The scantlings of floors are given in Table 1.5.1.

1.5.5 The length of arms of wooden forged or angle floors is measured from the corner following the external profile. The depth of plate floors is to be measured vertically.

1.5.6 At the hull ends the length of arms need not exceed one third of the frame span.

1.5.7 Wooden floors are to be made of suitably grained or laminated and their height at the ends is to be not less than the height of the throat.

1.5.8 Where the ballast keel bolts cross wooden floors the width of the latter at the throat is to be locally increased of necessary so as to be not less than three and a half times the diameter of the bolt.

1.5.9 Lugs for the connection of angle or plate floors to the wooden keel of penetrated by the ballast keel bolts are to have a flange width at least three times the diameter of the bolt and thickness equal to that of the plate floor plus 2.5 mm.

1.5.10 At the end of the hull when frames are continuous through the center structure by means of three through-bolts.

1.5.11 Floors are to be connected to frames by at least three bolts for arms with length l<250 mm and at least 6 bolts for greater l for diameters of bolts, see Table 1.5.2.

Table 1.5.1: Floors

Depth of the vessel D m	Floors on bent frames				Plate floors on grown or steel floors	
	Length of arms mm	forged floors		steel angles floors		
		at throat mm	at the ends mm	Section modulus cm^3	for 2/3 L amidships mm	outside 2/3 L amidships mm
1.6	220	25x6	15x6	0.3	120x3	100x3
1.8	250	25x6	15x6	0.3	150x3	110x3
2	280	25x8	16x6	0.3	170x3	130x3
2.2	310	25x10	18x6	0.6	200x3	145x3
2.4	350	25x10	19x6	1	230x3	170x4
2.6	375	26x13	20x6	1	270x3	180x4
2.8	405	27x14	22x6	1.2	280x4	190x4
3	430	29x15	24x6	1.4	300x5	200x4
3.2	465	31x16	25x6	1.4	320x5	220x4
3.4	495	33x17	27x6	1.5	330x5	230x4
3.6	530	35x17	28x6	1.5	340x6	240x4
3.8	-	-	-	-	345x6	245x4
4	-	-	-	-	350x6	250x4
4.2	-	-	-	-	360x6	260x5

Depth of the vessel D m	Floors on grown or laminated frames						
	Length of arms mm		forget floors		steel angle	wooden floors	
	for 3/5 L amidships mm	outside 3/5 L amidships mm	at throat mm	at the ends mm	section modulus cm^3	width mm	depth mm
1.6	350	230	19x9	19x9	0.34	20	40
1.8	380	250	25x10	20x10	0.36	23	55
2	410	280	31x12	27x10	0.71	26	68
2.2	150	320	38x14	33x10	1	31	80
2.4	180	350	44x16	40x10	1.2	36	95
2.6	510	380	48x18	43x10	1.2	42	108
2.8	550	400	52x20	47x10	1.9	47	120
3	580	430	56x22	50x12	2.4	51	135
3.2	610	460	60x24	52x13	3.6	56	148
3.4	650	500	64x26	54x14	5.7	60	160
3.6	680	530	69x28	56x16	6.9	64	170
3.8	720	560	73x30	58x17	6.9	70	180
4	750	590	77x31	61x18	9	75	190
4.2	780	620	80x31	63x20	10.6	80	200

Table 1.5.2: Floor Fastenings

Depth of the vessel D m	Diameter of bolts			
	at throat		in the arms	
	Grown or laminated or steel frames mm	Bent frames mm	Grown or laminated or steel frames mm	Bent frames mm
1.8	8	7	7	7
2	9	8	8	7
2.2	10	8	8	7
2.4	12	8	8	8
2.6	12	9	9	8
2.8	14	10	10	8
3	14	12	12	8
3.2	16	12	12	9
3.4	18	14	14	9
3.6	20	14	14	9
3.8	20	-	14	-
4	20	-	16	-
4.2	22	-	16	-

Fastenings of longitudinal structures			
Length of vessel L mm	Diameter of bolts		
	Centreline structures of ships mm	Scarphs and breasthook arms mm	Beam shelves and beam knees mm
14	14	11	8
16	16	11	8
18	18	12	10
20	18	14	11
22	20	14	11
24	20	14	11
26	20	14	11
28	22	16	12
30	22	18	14
32	23	19	15
34	24	20	16
36	25	21	17

1.6 Beams, Bilge stringer

1.6.1 Beam shelves

a) The cross sectional area of beam shelves through 0.6 L amidships is to be nor less than that indicated in Table 1.6.1. Outside such zone the cross section may be gradually decreased to reach at the end a value equal to 75% of that show.

b) Where beam shelves are made of two or more pieces the connection is to be effected by means of glued scarfs adequality arranged so as to be staggered in respect of the sheerstrake, waterway and bracket joints. Scarfs are generally arranged vertically.

c) When the weather deck is not continuous owing to the presence of raised decks the shelf is to extend to the hull end or alternatively stiffeners are to be fitted to prevent excessive discontinuity due to the interruption of suitable chocks.

d) The shelves are to be connected to each frame by a through bolt for heights ≤ 180 mm and by two through bolts for greater heights. If metal frames are adopted bolting of the shelf is to be effected on a reverse lug.

1.6.2 Beam clamps in way of mast

In way of masts a beam clamp is to be arranged of length approximately equal to the hull breadth in the same position. Such clamp with cross section equal to approximately 75% of that requited for shelves may be arranged so that its wider side is faying to the shelf or alternatively; it may be arranged below the shelf.

1.6.3 Bilge stringers

a) In hulls with type I or type III3 framing a bilge stringer is to be arranged having cross section may be decreased to reach at the ends a value equal to 75% of that required. The greater dimension of the stringer is to be arranged against the frames.

b) When the stringer is built of two or more pieces these are to be connected by means of glued scarfs parallel to the planking. Such scarfs are to be properly staggered in the port and starboard stringers and arranged clear of the joints of other longitudinal elements.

c) Where angle frames are adopted these are to be fitted for the connection between stringer and intermediate bent frames. In lieu of bilge stringer two side stringers having cross section equal to 60% of that required for the bilge stringer may be fitted.

d) The beam shelves and the stringers are to be connected to each other at the hull ends and with the centerline structure by means of suitable breasthooks or brackets.

e) The beam shelves and the stringers are to be connected to each other at the hull ends and with the centerline structure by means of suitable breasthooks or brackets. In hulls with exceptionally raked ends such breasthooks are to be given adequate attention.

Table 1.6.1: Beam shelves and bilge stringers

Length of the vessel m	**Cross sectional area of beam shelves, cm^2**	**Cross sectional area of bilge stringers, cm^2**
14	90	55
16	110	68
18	130	77
20	150	105
22	170	120
24	190	140
26	220	160
28	250	175
30	280	190
32	310	205
34	340	220
36	370	235

1.7 Beams

1.7.1 The scantlings of beams are given in Table 1.7.1. Where the spacing adopted is other than that shown in the table the scantlings following correction as necessary for the weight of the timber employed are to be modified in accordance with the following relationship:

$$\alpha_1 \cdot b_1{}^2 \geq a \cdot b^2 \cdot \frac{s_1}{s}$$

Where:

a, b= the width and height of the rule cross section,

a_1, b_1= the width and height of the modified cross section,

s= the rule spacing

s_1= the assumed spacing

Laminated beams may be reduced in width by 15%.

Table 1.7.1: Beams

Unsupported span of beam m	spacing mm	Ordinary beams for 3/5 L amidships: Width mm	Depth: at midbeam	Depth: at beam ends mm	Ordinary beams outside 3/5 L amidships, half beams: Width mm	Depth: at midbeam mm	Depth: at beam ends mm	Strong beams: Width mm	Depth: at midbeam mm	Depth: at beam ends mm
1.5	220	23	37	25	20	27	22	34	42	34
2	270	31	50	34	26	36	29	43	55	43
2.5	310	36	61	42	33	41	37	53	68	53
3	350	45	72	50	39	54	43	61	81	61
3.5	390	51	80	57	47	61	48	72	91	72
4	430	57	90	63	48	67	53	78	101	78
4.5	480	62	99	69	52	74	57	85	111	85
5	520	68	106	75	57	80	62	93	120	93
5.5	560	72	114	80	59	87	65	98	128	98
6	600	78	121	86	62	95	69	107	136	107
6.5	640	83	129	92	64	103	71	116	144	116
7	680	86	132	96	67	113	74	128	156	128
7.5	720	95	146	105	69	125	76	140	168	140

1.7.2 Beams are to be dovetailed on the shelf. When plywood deck planking is employed in place of the dovetail a simple dapping may be adopted having depth not less than 1/4 of the beam depth. In the case the beam is to be fastened to the shelf by means of a screw or pin.

1.7.3 Vertical knees are to be fitted to the extent required in Table 1.7.2 to strong beams and to suitable distributed ordinary beams. At the ends of the hull the length of knee arms may be not more than one third of the span of the beam or frame. Horizontal knees re to be fitted on way of hatch end beams and beams adjacent to mast wedging. These knees need not be arranged when plywood deck planking is adopted.

Table 1.7.2: Vertical knees of beams

Unsupported span of beam	Number of knees on each side	Length of arms		Forget knees		Steel angle knees	Plate thickness
m		for 3/5 L amidships mm	outside 3/5 L amidships	at throat mm	at the ends mm	section modulus cm^3	mm
1.5	3	280	220	20x7	17x4	0.25	3
2	4	320	250	23x10	20x5	0.4	3
2.5	4	360	290	27x13	24x6	0.8	3
3	5	400	320	34x17	30x7	1.7	4
3.5	6	440	350	41x20	37x7	3	4
4	7	490	390	48x23	42x8	4.3	4
4.5	8	530	420	53x26	46x9	5.9	5
5	9	570	450	57x28	49x10	7.5	5
5.5	10	610	490	62x30	52x11	9.3	5
6	10	650	520	67x32	54x12	11.5	6
6.5	11	700	560	72x34	55x14	14	6
7	12	740	590	78x35	57x16	16	6
7.5	12	780	620	81x37	58x17	19	7

1.7.4 The beams and decks shall be locally strengthened at the attachments of halliards, bollards, cleats, at skylight ends and on way of foundations of winches. All openings on deck shall be properly frames so as to constitute an effective support for half beams.

1.8 Planking

1.8.1 Shell planking

The basic thickness of shell planking is given in Table 1.8.1. If the frame spacing is other than that indicated in Table 7.1.2 the thickness is to be increased where there is greater spacing or may be reduced where there is smaller spacing by 6mm for every 100 mm of difference if type I framing is adopted, 4 mm for every 100 mm of difference if type II or III framing is adopted.

Table 1.8.1: Planking thickness

Length of the vessel, m	Shell and deck plating mm	Deck planking in deckhouses and coatchroofs mm	Coamings of coatchroofs mm
14	29	20	26
16	32	22	28
18	35	23	30
20	39	24	32
22	43.5	25	34
24	45.5	26	36
26	47.5	27	36
28	50	28	36
30	52	29	36
32	54	30	36
34	56	31	36
36	58	32	36

After correction for spacing as indicated above and for the weight of the timber where necessary the planking thickness may be reduced by 10% if arranged in diagonal or longitudinal double skin, by 10% if laminated and cold moulded in loco when the frames are reduced in scantlings by 25% in respect of the value given in Table 1.4.1. The thickness may be reduced by 25% where the frames have not been reduced in respect of the requirement of the table.

When plywood is employed the thickness may be reduced in relation to the type of framing adopted, the maximum reduction permitted is 25%.

1.8.2 Deck planking

a) The structure of the deck planking may be alltiverly as following:

- by planks parallel to the gunwale limited by a stringer board at side and by a kingplank at the centerline
- plywood
- plywood with associated planks

b) The thickness of the deck is given in Table 1.8.1 and is subject to the following modifications:

- if the beam spacing is other than that indicated in Table 1.7.1 the thickness is to be modified by 3mm for every 100mm of variation in spacing.
- if plywood if employed the thickness may be reduced by 30%
- if plywood is adopted in association with planking the specific mass of the plywood planking assembly is to be not less than 430 kg/m^3 and the combined thickness may be reduced by 30%.

1.8.3 Superstructures-Skylights

a) When coachroofs are adopted the opening on deck is to be well framed and the coaming on the weather deck is to be not less in thickness than that required in Table 1.8.1. The coachroofs deck is to have sheathing as prescribed in Table 1.8.1 which may be reduced in thickness in accordance with the spadifications on 1.8.2 for the weather deck. If the beam spacing is other than that indicated in Table 1.7.1 the thickness is to be modified by 3 mm for every 100 mm of difference in spacing.

b) When deckhouses are adopted they are to have a coaming fastened to the beams and carlings by means of through bolts. The structure of deckhouses is to be similar to that required for coachtoofs.

1.8.4 Mast and rigging

a) The scantlings of masts and rigging are left to the experience of builders and shipowners.

b) The mast step shall be of strong construction and shall be extended so as not to be connected to the hull. The wedging on deck shall be provided with watertight means.

c) When the mast rests on deck the underlying structure shall be strengthened in way such as to avoid giving way. If the mast rest on a coachroof the hull is to be strengthened in way by means of a bulkhead or a stiffened frame.

d) For shrouds and stays in wire and nor in rod the breaking loads of wires in galvanized steel 160 UNI 4434, in spiral shape, 1x19 wire and in stainless steel AISI 316 18/10 (ASTM-A 368-55) 1x19 wires in spiral shape are included below for information purposes.

Table 1.8.2: breaking loads of wires

Diameter, mm	Metallic cross section mm^2	Breaking load KN	
		Col. 1	Col. 2
3	5.37	7.75	7.36
4	9.55	13.73	13.73
5	14.2	21.1	20.6
6	21.5	30.9	29.43
7	29.2	41.69	40.22
8	38.2	54.94	52.97
10	59.7	65.73	83.39
12	86	122.63	117.72

1.9 Bulkheads

1.9.1 Wooden bulkheads

a) Wooden watertight bulkheads normally consist of plywood boards of adequate thickness in relation to the hull size and the spacing and strength of stiffeners.

b) The plywood normally arranged in vertical panels, shall be scarfed or strapped in way of vertical stiffeners. Connection to the hull shall be effected by means a grown or laminated frame and made watertight by packing where necessary.

1.9.2 Steel bulkheads

a) Steel watertight bulkheads are to be of thickness as shown in Table 1.9.1 as a function of the spacing of stiffeners and the height of the bulkhead. The scantlings are given on the assumption that the lowest strakes is horizontal and subsequent strakes vertical. When all strake are horizontal the thickness of the third and higher strakes may be decreased by a maximum of 0.5 mm per strake so as to reach a reduction of 25% in respect of the table thickness for the highest strake.

b) If the spacing is other than that shown in the table the thickness is to be modified by 0.5 mm for every 100 mm of difference in spacing. The spacing of vertical stiffeners is not to exceed 600 mm for the collision bulkhead.

Table 1.9.1: Watertight steel bulkheads

Height of bulkhead, m	Spacing of vertical stiffeners, mm	Thickness of lower strake, mm	Thickness of plate, mm
1.6	310	3	2.5
1.8	325	3	3
2	340	3.5	3
2.2	360	4	3.5
2.4	375	4	3.5
2.6	390	5	4.5
2.8	410	5	4.5
3	425	5.5	5
3.2	440	5.5	5
3.4	460	5.5	5
3.6	475	6	5.5
3.8	490	6	5.5
4	510	6	5.5
4.2	525	6	5.5
4.4	540	6.5	6
4.6	560	6.5	6
4.8	575	6.5	6
5	590	6.5	6

c) The scantlings of vertical stiffeners in cm^3 without end connections are to be not less than:

$$Z = (4.2 + 4 \cdot h) \cdot s \cdot S^2$$

Where:

Z= section modulus of vertical stiffener with associated strip of plating one spacing wide, cm^3

h= distance from midpoint of stiffener to top of bulkhead, m

s= spacing of vertical stiffeners, m

S= aggregate span of vertical stiffeners, m

d) The connection of the bulkhead to planking is to be effected on grown or laminated frames and provided with watertight packing where necessary.

1.10 Machinery space structure

1.10.1 The scantlings of floors web frames and foundation girders shall be adequate for the weight power and type of machinery. Their suitability and that of associated connections shall be satisfactory with particular regard to engine running and navigation tests when required by these rules.

SECTION 2 Structural scantlings of vessels with a chine hull

2.1 General

2.1.1 The scantlings in this chapter apply to motor vessels and/or motor-sailing vessels having length not exceeding 36 m with a chine hull and speed not greater than 40 knots. The craft which differ substantially from the above, as regards dimensions and/or vessels with round keels, the scantlings are determined by equivalence criteria.

2.2 Keel, Stempost

2.2.1 The minimum breadth of the keel and the aggregate cross sectional area of keel and hog frame are given in Table 2.2.1. Such scantlings are to be maintained up to the stem and while they may be reduced by 30% at the stern end.

2.2.2 Where they do not form one piece the keel and hog frame are to be scarfed. The scarfs are to be 6 times the thickness and of hooked or tabled type if bolted or of plain type if glued, the length may be reduced to not less than 4 times the thickness where the scarf is bolted glued. The keel scarfs are to be spaced not less than 1.5 meters apart from those of the hog frame.

Table 2.2.1: Keel and Stempost

Length of the vessel m	Keel		Stempost		
	minimum breadth mm	cross section of keel or keel and hog cm^2	width at heel and at head mm	cross section at heel cm^2	cross section at head cm^2
14	140	189	140	189	132
16	160	228	160	228	160
18	175	270	175	270	189
20	195	312	195	312	218
22	210	360	210	360	252
24	230	413	230	413	289
26	245	462	245	462	324
28	260	516	260	516	361
30	280	570	280	570	399
32	295	615	295	615	615
34	310	670	310	670	670
36	325	735	325	735	735

2.3 Transom

2.3.1 In chine hulls the sternpost is replaced by a transom. The transom structure consists of a frame having profile parts with a cross section not less than 120% of bottom frames, side frames or beams. Moreover the structures vertical stiffeners arranged in way of keel and bottom girders are to have a cross section with a height equal to that of the side frames and width increased by 50%.

2.3.2 The stiffeners above are generally to be spaced not more than 600 mm apart. The thickness of transom planking is to be equal to that given in Table 2.4.1 with any modifications required in accordance with those specified for shell planking.

2.4 Floors and frames

2.4.1 The ordinary framing of the hull is divided into three parts:

- bottom frames comprising those between the keel and the chine stringers
- side frames comprising those between the chine sringers and the waterways
- beams

2.4.2 The bottom frames generally made of two pieces one port and one starboard of the keel are butted in way of the centerline and connected by means of a double plywood floor. The side frames are in one piece connected to the bottom frames by means of double plywood brackets. The beams are connected to the side frames by means of double plywood brackets.

2.4.3 Bottom and side frames

Frame scantlings are given in Table 2.4.2 where three different types of frames are considered:

- Type I: solid or laminate frames of constant scantlings throughout the length of the hull
- Type II: solid or laminated frames alternated with one or two bent frames. Only the former are connected by means of floors and brackets.
- Type III: solid or laminated frames associated with bent longitudinal. This type of framing is to be associated with double skin cross planking or alternatively with plywood planking.

Table 2.4.1: Shell and deck planking

Length of the vessel m	Shell planking		weather deck planking mm	Deck of superstructures mm
	transverse framing mm	longitudinal mm		
14	21.5	17.5	21.5	17.5
16	25	21	25	19
18	27	24	27	21
20	29	25	29	21
22	31	27	31	21
24	32	28.5	32	21
26	34	30	34	21
28	36	32	36	21
30	37.5	33.5	37.5	21
32	39.5	35	39.5	21
34	42	37	42	21
36	44	38.5	44	21

Table 2.4.2: Frames

Depth of the vessel m	Type I framing (grown, or laminated frames)										
	spacing of web mm	Between keel and chine					Between chine and deck				
		Grown frames			Laminated frames		Grown frames			Laminated frames	
		width mm	depth at heel mm	depth at head mm	width mm	depth mm	width mm	depth at heel mm	depth at head mm	width mm	depth mm
1.9	237	24	60	54	24	47	24	50	44	24	43
2.1	255	26	72	65	26	56	26	60	55	26	51
2.3	270	28	82	75	27	61	28	70	63	28	56
2.5	288	30	96	88	30	71	30	81	74	30	65
2.7	305	32	112	102	32	82	32	93	84	32	75
2.9	322	35	127	116	35	93	35	103	90	35	85
3.1	340	39	140	127	39	104	39	117	108	39	94
3.3	355	44	148	135	44	113	44	122	110	44	103
3.5	375	50	162	148	50	125	50	131	115	50	114
3.7	390	55	178	162	55	135	55	143	123	55	125
3.9	408	60	200	182	60	157	60	156	130	60	143

Depth of the vessel m	Type II framing (grown or laminated frames with bent frames in between)				
	Spacing between main frames with alternated			Bent frames	
	one bent frame mm	two bent frames mm	three bent frames, mm	width mm	depth mm
1.9	410	520	590	26	17
2.1	446	540	620	30	19
2.3	460	570	640	31	20
2.5	490	590	670	33	22
2.7	515	620	695	34	23
2.9	560	650	730	36	25
3.1	590	690	770	38	27
3.3	620	725	800	40	30
3.5	-	-	-	-	-
3.7	-	-	-	-	-
3.9	-	-	-	-	-

Depth of the vessel m	Type III framing (grown, or laminated frames or bentwood longitudinal)										
	spacing of web mm	Between keel and chine					Between chine and deck				
		Grown frames			Laminated frames		Grown frames			Laminated frames	
		width mm	depth at heel mm	depth at head mm	width mm	depth mm	width mm	depth at heel mm	depth at head mm	width mm	depth mm
1.9	470	25	69	58	25	46	25	48	44	25	43
2.1	510	27	83	70	27	55	27	58	54	27	50
2.3	540	29	97	82	29	62	29	68	65	29	56
2.5	570	31	113	96	31	70	31	79	74	31	64
2.7	610	34	130	110	34	82	34	91	82	34	74
2.9	640	37	148	126	37	92	37	104	94	37	84
3.1	680	41	160	136	41	103	41	112	106	41	93
3.3	710	46	176	150	46	112	46	122	110	46	103
3.5	750	52	192	163	52	124	52	135	115	52	113
3.7	780	58	208	176	58	135	58	146	122	58	123
3.9	820	62	232	197	62	156	62	160	129	62	142

	Type III framing (grown or laminated frames or bentwood longitudinal)
Depth	Bentwood

of the vessel	longitudinal				
	spacing	Between keel and chine		Between chine and deck	
m	mm	width, mm	depth, mm	width, mm	depth, mm
1.9	210	33	20	33	17
2.1	225	37	23	37	19
2.3	240	39	25	39	20
2.5	255	41	27	41	22
2.7	270	43	28	43	23
2.9	285	45	30	45	25
3.1	300	48	33	48	27
3.3	315	50	36	50	30
3.5	330	53	39	53	33
3.7	345	55	42	55	36
3.9	360	58	45	58	39

2.4.4 Floors

The floors connecting bottom frames shall have thickness equal to half that required for the latter extend at the vessels centerlines to a height not less than twice that prescribed for the heel of such frames and overlap the frames by a distance not less than 2.5 times their depth so as to constitute an effective connection by means of glue and clenched volts. The space between the two levelers above the frames shall be fitted with a chock. Alternatively the frames nay be shafted so as to have at the centerline a depth above the keel equal to that required for the heel of the frames.

2.4.5 Frame and beam brackets

a) The connection of bottom frames to side frames and of the latter to beams is to be achieved be means of double brackets similar to those described for floors but overlapping both frames and beams by a distance not less than twice their respective depths.

b) In lieu of the brackets above the frame beam connection may be effected by simply overlapping preferably dovetailing the beam on the shelf and provided that transverse bulkheads are arranged with spacing not exceeding approximately 2 meters so as to constitute main transverse strengthening element of the hull and that no superstructure is arranged on the weather deck.

2.5 Side girders and longitudinal

2.5.1 On bottom frames at least two continuous girders are to be fitted each side with a cross section not less than $30cm^2$ for $L \leq 14$ meters, not less than $90cm^2$ for $L \geq 20$ meters and intermediate values for L between 15L between 14 and 20 meters.

2.5.2 For hulls with L>15 meters such girders continuous over bottom frames are to be connected to the bottom planking by means of chocks between frames set on a bent longitudinal continuous through the floors and connected to the planking. The chocks and the bent longitudinal may be omitted but in such case the bottom planking thickness given in Table 2.4.1 is to be augmented such as to achieve a cross section throughout the bottom increased by at least half that of the longitudinal.

2.5.3 A similar longitudinal but with a cross section reduced to 0.65 of those described above and nor fastened to the planking is to be fitted on side frames of hulls with L>14 meters. Such longitudinal may be omitted where type III framing is adopted.

Table 2.5.1: Cross section area of beam shelves & chine stringers

Length of the vessel, m	Cross section area of beams shelves, cm^2	Cross section area of chine stringers, cm^2
14	45	52
16	55	64
18	65	72
20	75	84
22	85	96
24	95	112
26	110	128
28	125	140
30	140	152
32	155	165
34	165	180
36	175	195

2.6 Beams

2.6.1 The arrangement of beams shall generally be carried out as follows:

- for hulls with type I framing ,beams on every frame
- for hulls with type II or III framing, beams on way of solid or laminated frames with bracket connection and intermediate beams without brackets let into the shelf.

2.6.2 Beams are to have width equal to that of the frames to which they are connected and section modulus in, cm^3, not less than:

$$Z_1 = K_1 \cdot a \cdot s$$

At the ends of large openings beams are to be fitted having a section modulus, in cm^3, not less than:

$$Z_2 = K_2 \cdot a \cdot s$$

where:

Z_1, Z_2 = section modulus of beams without planking contribution in cm^3

a= width of beams, in cm

s= beam spacing, in cm

K_1, K_2 = coefficient given by the following Table 2.6.1 as a function of the beam span.

Table 2.6.1: Coefficients K_1, K_2

Beam span	Coefficients for calculation of beam section modulus			
	K_1		K_2	
m	at the centerline	at the ends	at the centerline	at the ends
1.2	9.4	4.26	17.1	8.7
2	14.3	6.43	23	11.4
2.5	18	8.5	3	15.1
3	22.2	10.7	38.6	17.7
3.5	24.7	12.5	43.6	22.2
4	28.3	13.9	48.7	23.6
4.5	30.6	14.9	52.5	25.2
5	32.4	16.3	56.8	27.7
5.5	35.1	17.1	60	28.7
6	36.9	18.1	63.5	31.8
6.5	38.7	19.5	70	35
7	39.6	20.5	73.5	40.2
7.5	40.5	23	81	45.4

2.6.3 Where laminated beams are arranged the section modulus Z_1, Z_2 may be reduced of those indicated above.

2.7 Beam shelves and chine stringers

2.7.1 The cross sectional area of beam shelves and chine stringer is to be not less than that given by the following Table 2.5.1 as a function of L and to have the ratio h/t<3 where h is the depth and t the thickness of the bar. The cross section of shelves and stringers is to be considered as inclusive of the dappings for beam and frame ends.

2.8 Shell planking

2.8.1 The basic thickness of shell planking is given in Table 2.4.1. If the frame spacing is other than that shown in Table 2.4.2 the planking thickness is to be increased or may be reduced accordingly by 10% for every 10 mm of difference. After correction for spacing the planking thickness may be reduced:

- by 10% of a diagonal or longitudinal double skin planking is adopted.
- by 15% of composite planking constituted by inner plywood skin and one or two outer longitudinal diagonal strakes is adopted
- by 25% if laminated planking or plywood is adopted

2.8.2 Vessels with speed>25 knots are to have bottom frames stiffened in respect of the scantlings in this article and planking thickness increased as follows

- speed from 26 to 30 knots: 5%
- speed from 31 to 35 knots: 10%
- speed from 36 to 40 knots: 15%

2.8.3 When the deadrise is between 25º and 30º and outer longitudinal strakes are fitted on the bottom planking the above increase in thickness may be reduced but generally not less than half of the percentage values above.

2.9 Deck planking

2.9.1 Weather deck

a) Deck planking may be constituted by planks limited by a stringer board at side and by a kingplank at the centerline. Such planking may be solely plywood or plywood with associated planking arranged as described above.

b) The thickness of deck planking is given in Table 2.4.1 of the beam spacing is other than that prescribed in Table 2.4.2 the planking thickness is to be increased or may be reduced accordingly by 10% for every 100 mm of difference.

c) After correction for spacing the planking thickness may be reduced:

1. by 30% of plywood or plywood associated with planking is employed.

Moreover the plywood thickness is to be not less than 30% of the total thickness or less than 6 mm.

2.9.2 Superstructure decks

The thickness of planking of superstructure decks is given in Table 2.4.1.

2.9.3 Lower deck

In hulls with depth measured between the upper keel side and the weather deck beam greater than or equal to 3.1 meters a lower or cabin deck is to be arranged with beams having a section modulus not less than 60% of that prescribed in article 2.6 for weather deck beams and effectively fastened to the sides by means of a shelf with a cress sectional area nor less than 2/3 of that required in Table 2.5.1.

When the depth as measured above exceeds 4.3 meters the fastening of beams to side is to be completed by means of plywood brackets arranged at least at every second beam and having scantlings as prescribed in 2.4.5. The scantlings of the deck planking are to be not less than those required in 2.9.2.

CHAPTER 8 EQUIPMENT

SECTION 1 General

1.1 Application

1.1.1 The requirements in this Chapter apply to equipment and installation for anchoring and mooring. Requirements for towlines are not a subject of Classification. However, lengths and breaking strengths are given as guidance in SECTION 6**.**

1.1.2 For ships intended to operate only in special areas or conditions which have been approved by the Society, equipment differing from the requirements of this Chapter may be accepted, if considered in accordance to the particular service on which they are to be engaged.

1.2 Plans to be submitted

1.2.1 The following plans and particulars are to be submitted for approval:

a. Calculation of the equipment number.
b. Type of anchor, grade of anchor chain, type and breaking load of steel and fibre ropes.
c. Design of anchor if different from a standard type. Material specification.
d. Design of windlass and material specification.
e. Design of chain stopper and material specification.

1.2.2 Test certificates will be required for the following:

a. Anchor
b. Anchor chain cable
c. Windlass
d. Wire rope
e. Wire rope for mooring

SECTION 2 Equipment number - Equipment tables

2.1 Definition

2.1.1

a. The basic equipment number for determining the required equipment is to be calculated from the following equation:

$$EN = \Delta^{2/3} + 2 \cdot B \cdot H + 0{,}1 \cdot A$$

where:

Δ= Moulded displacement to the summer load waterline, in tones,
B= Breadth of ship, in m,
$H = \alpha + \sum h$, in m (see Figure 2.1.1)

α= Freeboard from the summer load waterline amidships, in m,

$\sum h$ = Sum of the heights on the centerline of each tier of deckhouses having a breadth greater than 0,25B, in m,

A= Sum of the profile area of the hull above summer load waterline, and of superstructures and deckhouses having a breadth greater than 0,25B, which are within the length of ship L, in m².

b. For vessels having EN of 200 or above the required equipment is to be obtained from Table 3.3.1, Table 3.3.3, and Table 3.3.4.

c. For vessels having EN according to (a) less than 200 the EN used for obtaining the required equipment from Table 3.3.1, Table 3.3.3, and Table 3.3.4 is to be calculated from the following equation:

$$EN = \Delta^{2/3} + 2\,(C + Ba) + 0{,}1\ \cdot A$$

where:

Δ= loaded displacement in tones.

bi= mean breadth of deckhouse or superstructure tier, in meters.

hi= mean height of deckhouse or superstructure tier in meters.

C= the sum of bi hi for all deckhouses and superstructures tiers.

α = The distance in meters, from the waterline to the underside of the first tier of deckhouse or superstructure.

B= Breadth of ship, in m.

A= Sum of the profile area of the hull above summer load waterline, and of superstructures and deckhouses having a breath greater than 0,25B, which are within the length of ship L, in m².

d. The equipment of yachts described in Table 3.3.2. The equipment number of yachts can be calculated according to 2.1.1 (a). For yachts that have superstructures with the front bulkhead with an angle of inclination aft, the “Equipment Number” can be calculated as follows:

$$EN = \Delta^{2/3} + 2\,(C + Ba) + 0{,}1\ \cdot A$$

where:

Δ= loaded displacement in tones.

bi= greatest breadth, of each tier n of superstructures or deckhouses having a breadth greater than B/4, in meters.

hi= height, in m, at the centerline of each tier n of superstructures or deckhouses having a breadth greater than B/4, in meters.

θi= angle of inclination with the horizontal axis aft of each front bulkhead

C= the sum of bi hi sinθi for all deckhouses and superstructures tiers.

a= the distance in meters, from the waterline to the underside of the first tier of deckhouse or superstructure.

B= Breadth of ship, in m.

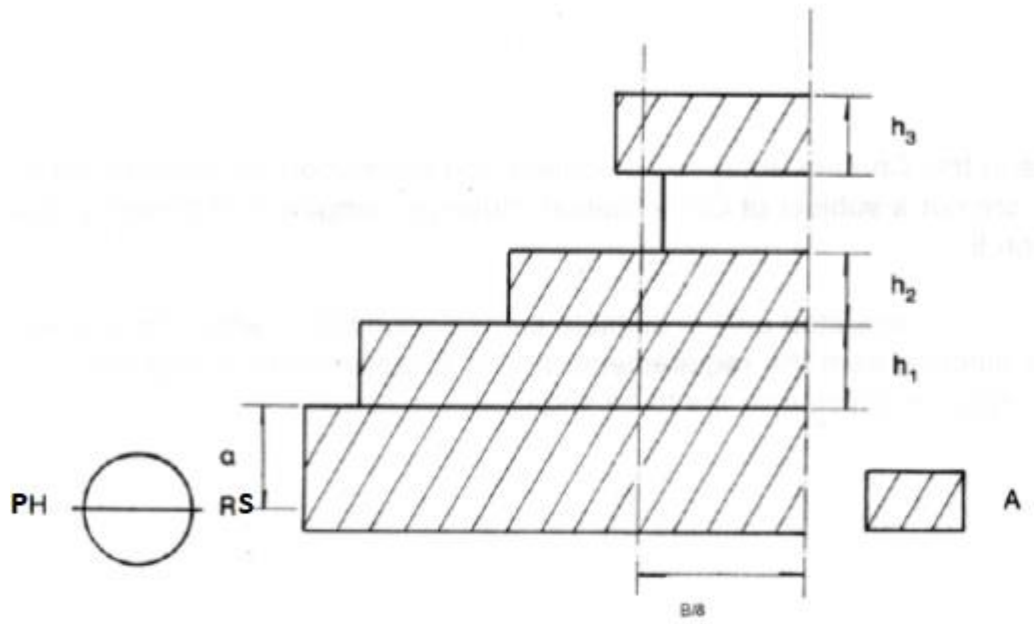
A= Sum of the profile area of the hull above summer load waterline, and of superstructures and deckhouses having a breath greater than 0,25B, which are within the length of ship L, in m².

2.1.2 When calculating H and A, sheer, camber and trim may be ignored. Windscreens and bulwarks more than 1,5 m in height are to be regarded as parts of superstructures or deckhouses when calculating H and A. Where the height of a windscreen or bulwark is not constant, the portion exceeding 1,5 m in height is to be included. Hatch coamings more than 1,5 m in height are to be included when calculating A.

2.1.3 The formula in 2.1.1 for the required anchoring equipment is based on the assumption that the current speed is 2,5 m/sec, the wind speed is 25 m/sec, and the scope of chain cable lies between 6 and 10. The scope is defined as the ratio between the length of chain paid out and the water depth. If the anchoring equipment is to be used in worse conditions special calculations should be given.

2.1.4 The required equipment of anchors and chain cables is suitable for temporary mooring of the vessel within a harbor, in sheltered waters or for use in emergencies. In the case the equipment is intended to be used in open sea operations (e.g. research ships) special considerations should be given.

Figure 2.1.1:



SECTION 3 Anchors

3.1 Anchor types

3.1.1 Anchors are usually of stockless type of an approved design. Anchors of stocked type may be also used. In the latter case, the mass of the stocked anchor, without the stock, is not to be less than 80% of the value given in Table 3.3.1 and Table 3.3.3 for ordinary stockless anchors. The mass of the stock is to be 20% of the total mass of the anchor including the shackle, etc., and the stock.

3.1.2 It is assumed that under normal circumstances the ship will use only one anchor and chain cable at a time.

3.1.3 The design of all anchor heads is to be such as to minimize stress concentrations. In particular, the radii on all parts of cast anchor heads are to be as large as possible, especially when there I considerable change of section.

3.1.4 The mass of each anchor given in Table 3.3.1 and Table 3.3.3 is for anchors of equal mass. The masses of individual anchors may vary ±7% of the masses given in Table 3.3.1 and Table 3.3.3, provided that the total mass of all anchors is not less than that required for anchors of equal mass. The mass of the head, including pins and fittings, of an ordinary stockless anchor is not to be less than 60% of the total mass of the anchor.

3.1.5 The anchors are normally housed in hawse pipes of suitable size and form in order to prevent movement of anchor and chain due to the motions of the ship. The deck arrangements must provide an easy way of the chain cable from the windlass to the anchor. Upon release of the brake, the anchor has to immediately start falling by its own weight. The radius of curvature of the upper end of the hawse pipe should be such that at least 3 link of chain bear simultaneously. Where hawse pipes are not fitted special arrangements should be given.

3.1.6 The shell plating in the area of the hawse pipes is to be increased in thickness and framing in such a way so that to ensure a rigid fastening of the hawse pipes to the hull of the ship.

3.2 Additional requirements for High Holding Power (HHP) and Super High Holding Power (SHHP) anchors

3.2.1 H.H.P. and S.H.H.P. anchors are designed for effective hold of the sea bed irrespective of the angle or position at which they first settle. If the anchor is not of a standard type, a demonstration of this property may be required.

3.2.2 Anchor of design for which approval as H.H.P. anchor is sought, is to be tested at sea to prove that it has a holding power per unit of mass at least twice the holding power of an ordinary stockless anchor of the same mass. In this case its weight may be reduced up to a maximum of 10% from weights specified in Table 3.3.1 and Table 3.3.3.

3.2.3 Anchor of design for which approval as S.H.H.P. anchor is sought, is to be tested at sea to prove that it has a holding power per unit of mass at least 4 times the holding power of an ordinary stockless anchor of the same mass. In this case its weight may be reduced up to a maximum of 20% from weights specified in Table 3.3.1 and Table 3.3.3.

3.2.4 The tests are to be conducted on at least 3 different types of bottom, which normally are to be soft mud or silt, sand or gravel, and hard clay or similarly compacted material.

3.2.5 If approval is sought for a range of anchor sizes, at least two sizes are to be tested. The smaller of them is to have a mass not less than 1/10 of the mass of the larger one. The larger one is to have a mass not less than 1/10 of that of the largest anchor for which approval is sought.

3.2.6 The tests should normally be carried out from a tug, and the pull measured by a dynamometer or derived from recently verified curves of tug bollard pull as a function of propeller rpm. A scope of 10 is recommended for the anchor cable, which may be a wire rope for these tests, but in no case a scope less than 6 is to be used. The same scope is to be used for the anchor for which approval is sought and the anchor that is being used for comparison purposes.

3.3 Materials - Manufacture

3.3.1 Forged or cast anchors and anchor components must be made of weldable carbon or carbon manganese steel with a carbon content not exceeding 0,22%, or 0,23% for cast steel.

3.3.2 Rolled steels for the manufacture of anchors of welded construction must meet the requirements specified in Chapter 8 of Part 2 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

Table 3.3.1: Equipment - Anchors and chain cables for small craft

Equipment number		Stockless anchors		Stud-link chain cables			
					Diameter (mm)		
Exceeding	Not exceeding	Number	Mass of anchor (Kg)	Total length (m)	Mild steel	Special quality steel	Extra special quality steel
30	40	2	80	192,5	12,5	-	-
40	50	2	100	192,5	12,5	-	-
50	60	2	120	192,5	14	12,5	-
60	70	2	140	192,5	14	12,5	-
70	80	2	160	220	16	14	-
80	90	2	180	220	16	14	-
90	100	2	190	220	17,5	16	-
100	110	2	240	220	17,5	16	-
110	120	2	270	247,5	19	17,5	-
120	130	2	300	247,5	19	17,5	-
130	140	2	340	275	20,5	17,5	-
140	150	2	390	275	20,5	17,5	-
150	160	2	450	275	22	19	-
160	170	2	475	275	22	19	-
170	180	2	500	302,5	24	20,5	-
180	190	2	530	302,5	24	20,5	-
190	200	2	560	302,5	24	20,5	-
200	220	2	615	302,5	26	22	20,5
220	240	2	670	302,5	26	22	20,5
240	260	2	725	330	28	24	22
260	280	2	780	330	28	24	22
280	300	2	840	357,5	30	26	24
300	320	2	900	357,5	30	26	24
320	340	2	955	357,5	32	28	24
340	360	2	1020	357,5	32	28	24
360	380	2	1080	385	34	30	26
380	400	2	1135	385	34	30	26
400	425	2	1290	385	36	32	28
425	450	2	1340	385	36	32	28
450	475	2	1390	412,5	38	34	30
475	500	2	1440	412,5	38	34	30
500	550	2	1590	412,5	40	34	30
550	600	2	1740	440	42	36	32
600	650	2	1920	440	44	38	34
650	700	2	2100	440	46	40	36
700	750	2	2220	467,5	48	42	36
750	800	2	2370	467,5	50	44	38
800	850	2	2460	467,5	50	44	38
850	900	2	2640	467,5	52	46	40
900	950	2	2850	495	54	48	42
950	1050	2	3060	495	56	50	44
1050	1150	2	3300	495	58	50	46

Table 3.3.2: Equipment – Anchors, chain cables and mooring lines for yachts

EN		Stockless bower anchors		Chain cables for anchors					Mooring lines		
A<EN≤B		No. (1)	Mass per anchor (kg)	Total length (m)	Diameter (mm)				No.	(2) Length (m)	Breaking load kN
					Studless chain cable	Chain cables with stud					
A	B					PHRS 1	PHRS 2	PHRS 3			
50	70	1	100	137,5	11	-	-	-	2	42	26
70	90	1	120	165	12,5	11	-	-	2	50	31
90	110	1	140	165	12,5	11	-	-	2	62	35
110	130	2	160	192,5	14,5	14	12,5	-	3	70	35
130	150	2	180	192,5	14,5	14	12,5	-	3	74	39
150	175	2	200	192,5	17,5	16	14	11	3	77	43
175	205	2	230	220	17,5	16	14	11	3	80	47
205	240	2	260	220	19	17,5	16	12,5	4	85	51
240	280	2	310	220	19	17,5	16	12,5	4	90	55
280	320	2	360	247,5	20,5	19	17,5	14	4	95	59
320	360	2	410	247,5	22	20,5	17,5	14	4	100	62
360	400	2	460	247,5	24	22	19	16	4	105	70
400	450	2	520	275	-	22	19	16	4	110	78
450	500	2	580	275	-	24	20,5	17	4	110	86
500	550	2	640	275	-	26	22	20,5	4	130	98
550	600	2	700	302,5	-	26	22	20,5	4	130	105
600	660	2	770	302,5	-	28	24	22	4	130	118
660	770	2	840	302,5	-	30	26	24	4	130	126
720	780	2	910	330	-	30	26	24	4	140	138
780	840	2	980	330	-	32	28	24	4	140	150
840	910	2	1060	357,5	-	32	28	24	4	140	160
910	980	2	1150	357,5	-	34	30	26	4	140	173
980	1060	2	1260	357,5	-	36	32	28	4	140	184

(1) The second anchor is intended as a spare and it is not necessary to carry it as a bower anchor provided that, in the event of the loss of the first anchor, the sheet anchor can be readily removed from its position and arranged as a bower anchor. The mass required for each anchor can be replaced with two anchors having a total mass not less than the mass of the anchor required. In this case the two anchors are to be in place, to be used simultaneously. In addition, the length of each chain line shall not be less than 70% of the total length indicated in the table.

(2) Length of each line.

Table 3.3.3: Equipment of fishing vessels-Bower anchors and chain cables

Equipment number		Stockless anchors				
					Diameter (mm)	
Exceeding	Not exceeding	Number	Mass of anchor (Kg)	Total length (m)	Mild steel	Special quality steel
30	40	2	80	165	11	-
40	50	2	100	192,5	11	-
50	60	2	120	192,5	12,5	-
60	70	2	140	192,5	12,5	-
70	80	2	160	220	14	12,5
80	90	2	180	220	14	12,5
90	100	2	210	220	16	14
100	110	2	240	220	16	14
110	120	2	270	247,5	17,5	16
120	130	2	300	247,5	17,5	16
130	140	2	340	275	19	17,5
140	150	2	390	275	19	17,5
150	175	2	480	275	22	19
175	205	2	570	302,5	24	20,5
205	240	2	660	302,5	26	22
240	280	2	780	330	28	24
280	320	2	900	357,5	30	26
320	360	2	1020	357,5	32	28
360	400	2	1140	385	34	30
400	450	2	1290	385	36	32
450	500	2	1440	412,5	38	34
500	550	2	1590	412,5	40	34
550	600	2	1740	440	42	36
600	660	2	1920	440	44	38
660	720	2	2100	440	46	40

Table 3.3.4: Equipment reduction for ships operating in restricted areas (These reductions are not applicable for yachts)

Class Notation	Stockless Bower anchors		Stud-link chain cables	
	Number	Mass change per anchor	Length reduction	Diameter
Coastal service	2	-10%	0%	0%
	1	40%	-40%	0%
Extended protected waters service	2	-20%	0%	-10%
	1	10%	-45%	0%
Protected waters service	2	-30%	-20%	-10%
	1	0%	-50%	0%

NOTE:
In the case of 'Specified route service' or 'Specific operating area service' notations the reduction will be specially considered.

3.3.3 Forged or cast anchors and anchor components must be normalized.

3.3.4 Anchor shackles must be made of forged or cast steel and must be properly heat treated.

3.3.5 Forged and cast steel must meet the requirements set out in Part 2 of "Rules and Regulations for the Classification and Construction of Steel Ships".

3.4 Quality of anchors

3.4.1 All anchors must be free from defects liable to impair their function, e.g. cracks, major casting and forging defects and improperly executed welds.

3.5 Testing and identification of anchors

3.5.1 For more details see Part 2, Chapter 8, Section 1 of "Rules and Regulations for the Classification and Construction of Steel Ships".

3.6 Repair and Testing of damaged anchors

3.6.1 For more details see Part 2, Chapter 8, Section 1 of "Rules and Regulations for the Classification and Construction of Steel Ships".

SECTION 4 Anchor chain cables

4.1 Cable types

4.1.1 Anchor cables are to be stud link chains of Grades PHRS-1, PHRS-2 or PHRS-3 (see 4.2) corresponding to the nominal diameter of chain and equipment number given in Table 3.3.1 and Table 3.3.3.

4.1.2 Chain cables are to be made by makers approved by the Society for the pertinent type of the chain cable, size and method of manufacture.

4.1.3 The form and proportion of chain cable links and shackles are to be in accordance with International Standard ISO/1704-1973.

4.1.4 If steel wire rope or ordinary short link chain cable is used instead of stud link chain cable, that is to have length equal to 1,5 times the corresponding tabular length of stud link chain cable and to be of strength equal to that of tabular stud link chain cable of grade A.

4.1.5 When chain cable is substituted by wire or synthetic fibre rope, a short length of chain cable is to be fitted between the anchor and wire rope. Its length is at least to be the distance between anchor in stowed position and windlass. Shorter length may be considered in special cases. The ropes are to be stored on drums protected from the weather and sea and are to be led over rollers in order to reduce wear and tear.

4.1.6 The chain locker is to have adequate capacity and suitable form to provide a proper stowage of the chain cable, and an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. Port and starboard cables are to have separate spaces. The chain locker boundaries and access openings are to be watertight. Adequate drainage facilities are to be adopted for the chain locker. Provisions are also to be made for securing the inboard ends of chain to the structure.

4.2 Materials

4.2.1 For more details see Part 2, Chapter 8, Section 2 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.3 Rolled steel bars

4.3.1 For more details see Part 2, Chapter 8, Section 2.4 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.4 Forged/cast steels

4.4.1 For more details see Part 2, Chapter 8, Section 2.5, 2.6 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.5 Materials for studs

4.5.1 For more details see Part 2, Chapter 8, Section 2.7 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.6 Design and manufacturing process

4.6.1 For more details see Part 2, Chapter 8, Section 2.8 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.7 Heat Treatment

4.7.1 For more details see Part 2, Chapter 8, Section 2.9 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.8 Mechanical properties

4.8.1 For more details see Part 2, Chapter 8, Section 2.10 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.9 Proof and breaking load properties

4.9.1 For more details see Part 2, Chapter 8, Section 2.11 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.10 Freedom from defects

4.10.1 For more details see Part 2, Chapter 8, Section 2.12 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.11 Dimensions and dimensional tolerances

4.11.1 For more details see Part 2, Chapter 8, Section 2.13 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.12 Weldings of studs

4.12.1 For more details see Part 2, Chapter 8, Section 2.14 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.13 Proof and breaking load tests of finished chain cables

4.13.1 For more details see Part 2, Chapter 8, Section 2.17 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.14 Re-tests and mechanical tests on Grade PHRS-2 and PHRS-3 finished chain cable

4.14.1 For more details see Part 2, Chapter 8, Section 2.17 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

4.15 Marking

4.15.1 For more details see Part 2, Chapter 8, Section 2.18 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

SECTION 5 Windlass and chain stoppers

5.1 Design

5.1.1 A windlass of sufficient power and suitable for the size of chain is to be fitted to the ship. The windlass is to have one cable lifter or wire drum for each anchor stowed in hawse pipe.

5.1.2 For each chain cable there is normally to be a chain stopper, arranged between windlass and hawse pipe.

5.1.3 The windlass unit prime mover is to be able to supply for at least 30 minutes a continuous duty pull, P, corresponding to the grade of the steel of which the cables are made of, and given by the following formula:

$$\begin{aligned} P &= 25 \cdot d^2 \quad N, \quad \text{for grade A} \\ &= 27.5 \cdot d^2 \quad N, \quad \text{for grade B} \\ &= 30 \cdot d^2 \quad N, \quad \text{for grade C} \end{aligned}$$

where:

d= Nominal diameter of common link, in mm (See Table 3.3.1 and Table 3.3.3)

For double windlasses the requirements apply to one side at a time.

5.1.4 The values of P include the influences of buoyancy and hawse pipe efficiency, which is assumed to be 70%.

5.1.5 The windlass unit prime mover is to provide the necessary temporary overload capacity for breaking out the anchor. The temporary overload capacity should not be less than 1,5 times the continuous duty pull and should be provided for at least two minutes. The speed in this period can be lower than the nominal speed.

5.1.6 The nominal speed of the chain cable when hoisting the anchor and cable can be a mean speed only and this speed should not be less than 0,15 m/sec. The speed is to be measured over two shots of chain cable during the total trip. The trial should be commenced with 3 shots (82,5 m) of chain fully submerged.

5.1.7 The capacity of the windlass brake is to be sufficient for safe stopping of the anchor and chain cable when paying out the chain cable. If a chain stopper is not fitted, the windlass is to be able to withstand a pull of 80% of the breaking load of the chain without any permanent deformation of the stressed part and without brake slip. If a chain stopper is fitted it should withstand a pull of 80% of the breaking load of the chain without any permanent deformation of the stressed part and without brake slip.

5.1.8 The windlass with brakes engaged and cable lifters disengaged is to be able to withstand a pull of 45% of the breaking load of the chain without any permanent deformation of the stressed parts and without brake slip.

5.1.9 The windlass and chain stoppers are to be efficiently bedded to the deck. The deck plating in the area of windlass and chain stopper is to be increased in thickness and supported by pillars carried down to rigid structures.

5.2 Materials

5.2.1 Cable lifter shafts are to be made from forged or rolled steel or from ordinary cast steel. Cable lifters are to be made from nodular cast iron or from ordinary cast steel. Chain stoppers may be cast or fabricated from plate materials. In the first case the material is cast steel or nodular cast iron with elongation not less than 18%.

5.3 Testing

5.3.1 Before assembly the following parts are to be tested:

a. housing with covers for hydraulic motors and pumps
b. hydraulic pipes
c. valves and fittings
d. pressure vessels

5.3.2 After completion, at least one prime mover of the windlass is to be tested with respect to required lifting and breaking forces.

5.3.3 After installation of the windlass on board, an anchoring test is to be carried out to demonstrate that the windlass functions satisfactorily. The mean speed on the chain cable when hoisting the anchor and chain cable is not to be less than 0,15m/sec, and is to be measured with a load at least corresponding to the total weight of 30% of the length of the chain cable or wire rope plus the weight of the anchor. The brakes are to be tested during lowering.

SECTION 6 Towlines and Mooring lines

6.1 Line types

6.1.1 The number, length and breaking strength of towlines and mooring lines for small crafts and light displacement crafts which are given in Table 6.2.1, are based on the Equipment Number calculated according to 2.1.

6.1.2 Towlines and mooring lines may be of wire, natural fiber or synthetic fiber, or a mixture of wire and fiber.

6.1.3 The lengths of individual mooring lines given in Table 6.2.1, may be reduced by 7%, provided that the total length of the mooring lines is not less than would have resulted if all lines had been of equal length.

6.1.4 In addition to the strength requirements given in Table 6.2.1 above, no fiber rope is to be less than 15 mm in diameter.

6.2 Steel wire ropes

6.2.1 Steel wire ropes are to be manufactured in works approved by the Society. The surveyors are to be allowed access to all relevant parts of the works.

6.2.2 Where steel wire ropes are used, they are to be made in equal lay construction, and are normally to be divided in groups as follows:

- x 19 Group consists of 6 strands with min. 16 and max. 27 wires in each strand
- x 36 Group consists of 6 strands with min. 27 and max. 49 wires in each strand

Other rope construction may be accepted by the Society upon special consideration.

6.2.3 Wire ropes for use in association with mooring winches where the ropes are to be stored on the drum may be constructed with an independent wire rope core instead of fiber core.

Table 6.2.1: Equipment - Tow lines and mooring lines for small craft

Equipment number		Tow line		Mooring lines		
Exceeding	Not Exceeding	Minimum length (m)	Minimum breaking strength (kN)	Number	Minimum length of each line (m)	Minimum breaking strength (kN)
30	40	170	80	2	80	30
40	50	170	80	2	80	30
50	60	180	80	2	80	32
60	70	180	80	2	80	32
		70				
70	80	180	100	2	100	35
80	90	180	100	2	100	35
90	100	180	100	2	100	38
100	110	180	100	3	100	38
110	120	180	100	3	110	42
120	130	180	100	3	110	42
130	140	180	100	3	120	46
140	150	180	100	3	120	46
150	160	180	110	3	120	50
160	170	180	110	3	120	50
170	180	180	110	3	120	55
180	190	180	110	3	120	55
190	200	180	110	3	120	60
200	220	180	125	3	120	60
220	240	180	125	3	120	66
240	260	180	125	3	120	66
260	280	180	150	3	120	72
280	300	180	150	3	140	72
300	320	180	175	4	140	78
320	340	180	175	4	140	78
340	360	180	200	4	140	84
360	380	180	200	4	140	84
380	400	180	225	4	140	90
400	425	180	225	4	140	90
425	450	180	250	4	140	96
450	475	180	250	4	140	96
475	500	180	275	4	140	102
500	550	190	300	4	160	120
550	600	190	325	4	160	130
600	650	190	350	4	160	145
650	700	190	400	4	160	155
700	750	190	425	4	170	165
750	800	190	450	4	170	175
800	850	190	500	4	170	185
850	900	190	525	4	170	200
900	950	190	550	4	170	215
950	1050	200	600	4	180	230
1050	1150	200	650	4	180	250

6.3 Manufacture and testing

6.3.1 The wires are to be drawn from steel manufactured by the open hearth, electric or basic oxygen furnace. Other processes may be specially approved by the Society. The wires are to be of homogeneous quality, consistent strength and free from visual defects likely to impair the performance of the rope.

6.3.2 The tensile strength is generally to be within the ranges 1420 to 1570 N/mm², 1570 to 1770 N/mm² or 1770 to 1960 N/mm².

6.3.3 The wire is to be galvanized by a hot dip or electrolytic process to give a continuous uniform coating which may be any of the following grades:

- Grade 1-heavy coating, drawn after galvanizing
- Grade 2-heavy coating, finally galvanized
- Grade 3-light coating, drawn after galvanizing

6.3.4 Torsion and zinc coating tests are to be carried out on wire samples taken from a suitable length of the completed rope. After unstranding and straightening, six wires are to be subjected to both a torsion test and a wrap test for adhesion of coating. Moreover, tests to determine the mass and uniformity of the zinc coating are to be carried out. As an alternative to test specimens specified above, tests may be carried out on the wire before the rope is stranded. These tests are to be made in accordance with ISO standard 2232.

6.4 Tests of completed ropes

6.4.1 The breaking load is to be determined by testing to destruction a sample cut from the completed rope. This sample is to be of sufficient length to provide a clear test length of at least 30 times the rope diameter between the grips.

6.4.2 Not more than four-fifths of the nominal breaking load may be applied quickly, and thereafter the load is to be applied slowly and steadily until the maximum load is obtained. Tests in which a breakage occurs adjacent to the grips may , at the option of the manufacturer, be neglected. The actual breaking load is to be not less than that given in an appropriate national standard.

6.4.3 If facilities are not available for making a breaking test on completed ropes, consideration will be given to the acceptance of the determination of the breaking load by the summation of the tests of individual wires. A percentage deduction is to be applied to the calculated breaking load to compensate for laying up. This percentage is to be not less than that given in Table 6.4.1.

Table 6.4.1: Laying up deduction on the calculated breaking load

Construction of rope	Percentage deduction (see Note)
6x19	13
6x36	17,5

NOTE :

Percentage deductions for other constructions should either be in accordance with a recognized national standard or are to be established by breaking tests carried out on completed ropes.

6.4.4 Manufacturers desiring to adopt the method of testing described in 6.4.3 may be required to arrange for check breaking tests to be carried out on completed ropes.

6.5 Marking

6.5.1 All completed ropes are to be identified with attached labels detailing the rope type, diameter and length.

6.5.2 Where ropes have been tested in the presence of the Surveyor, each rope length is to be additionally identified with a lead seal stamped with the Surveyor's personal marking.

6.6 Certification

6.6.1 When tests have not been witnessed by the Surveyor, manufacturers are authorized to complete and issue the Society's printed certificate forms. These forms are available on request.

6.6.2 In cases where purchasers require tests to be witnessed by the Surveyor, certificates will be issued by the Society.

6.7 Manufacture of fiber ropes

6.7.1 Fiber ropes intended as mooring lines may be made of coir, hemp, manila or sisal, or may be composed of synthetic fibers. They may be three-strand (hawser laid), four-strand(shroud laid) or nine-strand (cable laid), but other constructions will be specially considered.

6.7.2 Each length of rope is to be manufactured from suitable material of good and consistent quality. Rope materials should, in general, comply with a recognized national standard.

6.7.3 Synthetic fiber ropes are to be suitable for the purpose intended and should comply with a recognized standard.

6.7.4 Weighting and loading matter is not to be added, and any lubricant is to be kept to a minimum. Any rot-proofing or water repellence treatment is not to be deleterious to the fiber nor is it to add to the weight or reduce the strength of the rope.

6.8 Tests of completed ropes

6.8.1 The breaking load is to be determined by testing to destruction a sample cut from the completed rope.

6.8.2 The minimum test length and the initial test load are to be as given in Table 6.8.1. After application of the initial load, the diameter and evenness of lay up of the sample are to be checked. The sample is then to be uniformly strained at the rate given in Table 6.8.1 until it breaks.

Table 6.8.1: Breaking load test

Material	Test length (mm) minimum	Initial load (%) (see Note)	Rate of straining (mm/min.)
Natural fibre	1800	2	150 ± 50
Synthetic fibre	900	1	100 max.

NOTE : Percentage of specified minimum breaking load.

6.8.3 The actual breaking load is to be not less than that given in an appropriate national standard.

6.8.4 If the sample is held by grips and the break occurs within 150 mm of the grips, the test may be repeated, but not more than two tests may be made on any one coil.

6.8.5 Where difficulty is experienced in testing a sample of a completed synthetic fiber rope, the Society will consider alternative methods of testing.

6.9 Marking

6.9.1 Each coil of rope is to be identified with an attached label detailing the material, construction, diameter and length.

6.10 Certification

6.10.1 Printed certificates issued by the manufacturer or a competent governmental, municipal or similar responsible body will be accepted. These certificates are to give the breaking load, test length and rate of straining.

6.11 Winches

6.11.1 Each winch should be fitted with drum brakes the strength of which is sufficient to prevent unreeling of the mooring line when the rope tension is equal to 80% of the breaking strength of the rope as fitted on the first layer. Where this is achieved by the winch being fitted with a pawl and ratchet or other positive locking device, the breaking mechanism should be such that the winch drum can be released in a controlled manner while the mooring line is under tension.

6.11.2 For powered winches the maximum hauling tension which can be applied to the mooring line (the reeled first layer) should not be less than 0,22 times the rope’s breaking strength and not more than 0,33 times that strength. For automatic winches these figures should apply when the winch is set on the maximum power with automatic control.

6.11.3 The rendering tension which the winch can exert on the mooring line (reeled first layer) should not exceed 1,5 times, nor be less than 1,05 times the hauling tension for that particular power setting of the winch on automatic control.

6.11.4 The winch is to be marked with the range of rope strength for which it is designed.

CHAPTER 9 RUDDERS

RUDDERS

SECTION 1 General

1.1 Application

1.1.1 The following requirements are based on *IACS UR S10 (Corr. May 2018)* and apply to ordinary profile rudders and to some enhanced profile rudders with special arrangements for increasing the rudder force.

1.1.2 This rules apply to rudders made of steel.

1.2 Design considerations

1.2.1 Effective means are to be provided for supporting the weight of the rudder without excessive bearing pressure, e.g. by a rudder carrier attached to the upper part of the rudder stock. The hull structure in way of the rudder carrier is to be suitably strengthened.

1.2.2 Suitable arrangements are to be provided to prevent the rudder from lifting.

1.2.3 In rudder trunks which are open to the sea, a seal or stuffing box is to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier. If the top of the rudder trunk is below the deepest waterline two separate stuffing boxes are to be provided.

1.3 Materials

1.3.1 Rudder stocks, pintles, coupling bolts, keys and cast parts of rudders are to be made of rolled, forged or cast carbon manganese steel in accordance with Part 2 of “Rules and Regulations for the Classification and Construction of Steel Ships”.

1.3.2 For rudder stocks, pintles, keys and bolts the minimum yield stress is not to be less than 200 N/mm². The following requirements are based on a material's yield stress of 235 N/mm². If material is used having a yield stress differing from 235 N/mm² the material factor is to be determined as follows:

$$k = \left(\frac{235}{\sigma_F}\right)^e$$

e= 0,75 for $\sigma_F > 235$ N/mm²

e= 1,00 for $\sigma_F \leq 235$ N/mm²

σ_F= yield stress (N/mm²) of material used, and is not to be taken greater than $0{,}7 \cdot \sigma_T$ or 450 N/mm², whichever is the smaller value

σ_T= tensile strength (N/mm²) of material used

1.3.3 Before significant reductions in rudder stock diameter due to the application of steels with yield stresses exceeding 235 N/mm² are granted, the Society may require the evaluation of the rudder stock deformations. Large deformations should be avoided in order to avoid excessive edge pressures in way of bearings.

1.3.4 Welded parts of rudders are to be made of approved rolled hull materials. Required scantlings may be reduced when higher tensile steels are applied. The material factor according to 1.3.2 is to be used.

1.4 Welding and design details

1.4.1 Slot-welding is to be limited as far as possible. Slot welding is not to be used in areas with large in-plane stresses transversely to the slots or in way of cut-out areas of semi-spade rudders.

1.4.2 When slot welding is applied, the length of slots is to be minimum 75 mm with breadth of 2 t, where t is the rudder plate thickness, in mm. The distance between ends of slots is not to be more than 125 mm. The slots are to be fillet welded around the edges and filled with a suitable compound, e.g. epoxy putty. Slots are not to be filled with weld.

1.4.3 Continuous slot welds are to be used in lieu of slot welds. When continuous slot welding is applied, the root gap is to be between 6-10 mm. The bevel angle is to be at least 15°.

1.4.4 In way of the rudder horn recess of semi-spade rudders, the radii in the rudder plating are not to be less than 5 times the plate thickness, but in no case less than 100 mm. Welding in side plate is to be avoided in or at the end of the radii. Edges of side plate and weld adjacent to radii are to be ground smooth.

1.4.5 Welds between plates and heavy pieces (solid parts in forged or cast steel or very thick plating) are to be made as full penetration welds. In way of highly stressed areas e.g. cut-out of semi-spade rudder and upper part of spade rudder, cast or welding on ribs is to be arranged. Two sided full penetration welding is normally to be arranged. Where back welding is impossible welding is to be performed against ceramic backing bars or equivalent. Steel backing bars may be used and are to be continuously welded on one side to the heavy piece.

1.5 Equivalence

1.5.1 PHRS may accept alternatives to requirements given in this Chapter, provided they are deemed to be equivalent.

1.5.2 Direct analyses adopted to justify an alternative design are to take into consideration all relevant modes of failure, on a case by case basis. These failure modes may include: yielding, fatigue, buckling and fracture. Possible damages caused by cavitation are also to be considered.

1.5.3 If deemed necessary by the Society, lab tests, or full scale tests may be requested to validate the alternative design approach.

SECTION 2 Rudder force and torque

2.1 Rudder blades without cut-outs

2.1.1 The rudder force upon which the rudder scantlings are to be based is to be determined from the following formula:

$$C_R = K_1 \cdot K_2 \cdot K_3 \cdot 132 \cdot A \cdot V^2, \qquad N$$

Where:

$C_R =$ rudder force, N;

A= area of rudder blade, m²;

V= maximum service speed (knots) with the ship on summer load waterline. When the speed is less than 10 knots, V is to be replaced by the expression: $V_{min} = \frac{V+20}{3}$

For the astern condition the maximum astern speed is to be used, however, in no case less than:

$$V_{astern} = 0{,}5 \cdot V$$

$K_1 =$ factor depending on the aspect ratio λ of the rudder area

$K_1 = \frac{\lambda+2}{3}$, with λ not to be taken greater than 2

$K_2 =$ to be obtained from Table 2.1.1:.

$\lambda = \frac{b^2}{A_t}$

b= mean height of the rudder area, m. Mean breadth and mean height of rudder are calculated according to the coordinate system in Figure 2.1.1:.

A_t= sum of rudder blade area A and area of rudder post or rudder horn, if any, within the height b, m²

K_3= 0,8 for rudders outside the propeller jet;

= 1,15 for rudders behind a fixed propeller nozzle

= 1,0 otherwise

Figure 2.1.1:

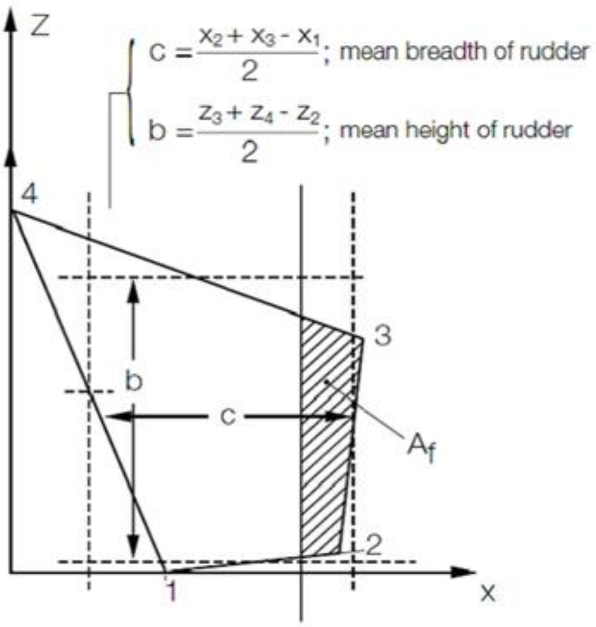
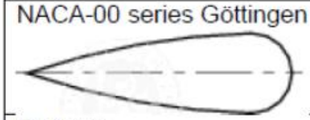
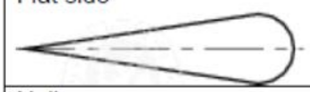
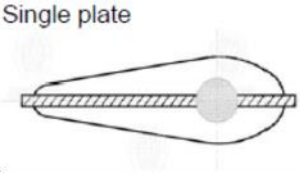


Table 2.1.1:

Profile Type	K_2	
	Ahead condition	**Astern condition**
NACA-00 series Göttingen 	1.10	0.80
Flat side 	1.10	0.90
Hollow 	1.35	0.90
High lift rudders 	1.70	to be specially considered; if not known: 1.30
Fish tail 	1.40	0.80
Single plate 	1.00	1.00
Mixed profiles (e.g. HSVA)	1.21	0.90

2.1.2 The rudder torque is to be calculated for both the ahead and astern condition according to the formula:

$$Q_R = C_R \cdot r, \qquad Nm$$

Where:

$r = c\ (a - k_1)$, m

c= mean breadth of rudder area, m, see Figure 2.1.1:.

$\alpha = 0{,}33$ for ahead condition

$\alpha = 0{,}66$ for astern condition

k_1= balance factor, as follows:

$k_1 = A_f/A$, where A_f= portion of the rudder blade area situated ahead of the center line of the rudder stock

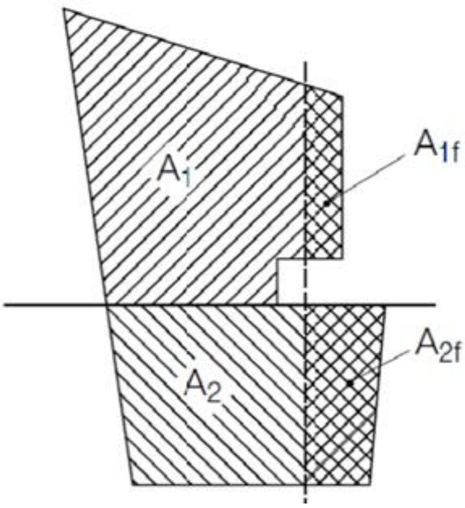
$r_{min} = 0{,}1 \cdot c$, for ahead condition, in m

2.2 Rudder blades with cut-outs (semi-spade rudders)

2.2.1 The total rudder force CR is to be calculated according to 2.1.1. The pressure distribution over the rudder area, upon which the determination of rudder torque and rudder blade strength is to be based, is to be derived as described in 2.2.2.

2.2.2 The rudder area may be divided into two rectangular or trapezoidal parts with areas A_1 and A_2, so that $A = A_1 + A_2$ (see Figure 2.2.1:).

Figure 2.2.1:



2.2.3 The levers r_1 and r_2 are to be determined as follows:

$r_2 = c_2 \cdot (a - k_2)$, m

$r_1 = c_1 \cdot (a - k_1)$, m

c_1, c_2= mean breadth of partial areas A_1, A_2, determined, where applicable, in accordance with Figure 2.1.1:.

$k_1 = A_{1f} / A_1$

$k_2 = A_{2f} / A_2$

$\alpha = 0,33$ for ahead condition

$\alpha = 0,66$ for astern condition

For parts of a rudder behind a fixed structure such as rudder horn:

$\alpha = 0,25$ for ahead condition

$\alpha = 0,55$ for astern condition

2.2.4 The resulting force of each part may be taken as:

$C_{R1} = C_R \, A_1/A$, N

$C_{R2} = C_R \, A_2/A$, N

2.2.5 The resulting torque of each part may be taken as:

$Q_{R1} = C_{R1} \cdot r_1$, Nm

$Q_{R2} = C_{R2} \cdot r_2$, Nm

The total rudder torque is to be calculated for both the ahead and astern condition according to the formula:

$$Q_R = Q_{R1} \cdot Q_{R2}, \qquad Nm$$

For ahead condition Q_R is not to be taken less than:

$$Q_{Rmin} = \frac{0,1 \cdot C_R(A_1 \cdot c_1 + A_2 \cdot c_2)}{A}$$

SECTION 3 Rudder stock

3.1 Rudder stock scantlings in way of the tiller

3.1.1 The rudder stock diameter required for the transmission of the rudder torque is to be dimensioned such that the torsional stress will not exceed the following value:

$$\tau_t = {}^{68}/_{k}\,, \qquad {}^{N}/_{mm^2}$$

3.1.2 The rudder stock diameter, in mm, for the transmission of the rudder torque is therefore not to be less than:

$$d_t = 4{,}2 \cdot \sqrt{Q_R \cdot k}$$

Where:

Q_R = total rudder torque as calculated in 2.1 or 2.2, Nm.

For the application of the material factor k see also 1.3.1.

3.2 Rudder strength calculations

3.2.1 The rudder force and resulting rudder torque as given in causes bending moments and shear forces in the rudder body, bending moments and torques in the rudder stock, supporting forces in pintle bearings and rudder stock bearings and bending moments, shear forces and torques in rudder horns and heel pieces. The rudder body is to be stiffened by horizontal and vertical webs enabling it to act as bending girder.

3.2.2 The bending moments, shear forces and torques as well as the reaction forces are to be determined by a direct calculation or by an approximate simplified method considered appropriate by the Society. For rudders supported by sole pieces or rudder horns these structures are to be included in the calculation model in order to account for the elastic support of the rudder body. Guidelines for calculation of bending moment and shear force distribution are given in SECTION 9.

3.2.3 Rudder stock scantlings due to combined loads

If the rudder stock is subjected to combined torque and bending the equivalent stress in the rudder stock is not to exceed 118/k N/mm².

The equivalent stress is to be determined by the formula:

$$\sigma_c = \sqrt{\sigma_b{}^2 + 3\,\tau_t{}^2}, \qquad {}^{N}\!/_{mm^2}$$

Where:

Bending stress: $\sigma_b = 10.2 \cdot 10^3 \cdot {}^{M}\!/_{d_c{}^3}$ N/mm²

Torsional stress: $\tau_t = 5.1 \cdot 10^3 \cdot {}^{Q_R}\!/_{d_c{}^3}$ N/mm²

The rudder stock diameter is therefore not to be less than:

$$d_c = d_t \cdot \sqrt[6]{1 + \left({}^{4}\!/_{3}\right) \cdot \left({}^{M}\!/_{Q_R}\right)^2}, \qquad mm$$

Where:

M= bending moment at the station of the rudder stock considered, Nm

SECTION 4 Rudder blade

4.1 Rudder blade scantlings

4.1.1 Permissible stresses
The section modulus and the web area of a horizontal section of the rudder blade made of ordinary hull structural steel are to be such that the following stresses will not be exceeded:

a. rudder blades without cut-outs (Figure 2.1.1)
   I. Bending stress σ_b , $^{110}/_{k}$, $^{N}/_{mm^2}$
   II. Shear stress τ $^{50}/_{k}$, $^{N}/_{mm^2}$
   III. equivalent stress $\sigma_c = \sqrt{\sigma_b{}^2 + 3\,\tau^2}$ $^{120}/_{k}$, $^{N}/_{mm^2}$

b. rudder blades with cut-outs (e.g. semi-spade rudders. Figure 2.2.1)
   I. Bending stress σ_b , $^{110}/_{k}$, $^{N}/_{mm^2}$
   II. Shear stress τ $^{50}/_{k}$, $^{N}/_{mm^2}$
   III. equivalent stress $\sigma_c = \sqrt{\sigma_b{}^2 + 3\,\tau^2}$ $^{120}/_{k}$, $^{N}/_{mm^2}$

Note: The stresses in b) apply equally to high tensile and ordinary steels.

4.2 Rudder plating

4.2.1 The thickness of the rudder side, top and bottom plating made of ordinary hull structural steel is not to be less than:

$$t = 5.5\ \cdot s\ \cdot \beta\ \cdot \sqrt{\kappa}\ \cdot \sqrt{\frac{d + C_R\ .\ 10^{-4}}{A}} + 2.5\ , \qquad mm$$

Where:

d= summer loadline draught of the ship, m

C_R= rudder force according to 2.1.1, N

A= rudder area, m^2;

β= 1,1 - 0,5 · (s / b)^2 max. 1,00 if b/s > 2,5

s= smallest unsupported width of plating, m

b= greatest unsupported width of plating, m.

k= material factor for the rudder plating as given in 1.3.1.

4.2.2 The thickness of the nose plates may be increased to the discretion of the Society. The thickness of web plates is not to be less than 70% of the rudder side plating, however, not less than 8 mm.

4.3 Connections of rudder blade structure with solid parts

4.3.1 Solid parts in forged or cast steel, which house the rudder stock or the pintle, are to be provided with protrusions, except where not required as indicated below.

4.3.2 These protrusions are not required when the web plate thickness is less than:

- 10 mm for web plates welded to the solid part on which the lower pintle of a semi-spade rudder is housed and for vertical web plates welded to the solid part of the rudder stock coupling of spade rudders.
- 20 mm for other web plates.

4.3.3 The solid parts are in general to be connected to the rudder structure by means of two horizontal web plates and two vertical web plates.

4.3.4 Minimum section modulus of the connection with the rudder stock housing.

4.3.5 The section modulus of the cross-section of the structure of the rudder blade, in cm³, formed by vertical web plates and rudder plating, which is connected with the solid part where the rudder stock is housed is to be not less than:

$$W_s = c_s \cdot {d_c}^3 \cdot \left(\frac{H_E - H_X}{H_E}\right) \cdot \frac{k}{k_s} \cdot 10^{-4}\,, cm^3$$

Where:

c_s = coefficient, to be taken equal to:
= 1,0 if there is no opening in the rudder plating or if such openings are closed by a full penetration welded plate
= 1,5 if there is an opening in the considered cross-section of the rudder
d_c= rudder stock diameter, in mm
H_E= vertical distance between the lower edge of the rudder blade and the upper edge of the solid part, in m
H_X= vertical distance between the considered cross-section and the upper edge of the solid part, in m
k= material factor for the rudder plating as given in 1.3.1.
k_s= material factor for the rudder stock as given in in 1.3.1.

4.3.6 The actual section modulus of the cross-section of the structure of the rudder blade is to be calculated with respect to the symmetrical axis of the rudder.

4.3.7 The breadth of the rudder plating, in m, to be considered for the calculation of section modulus is to be not greater than:

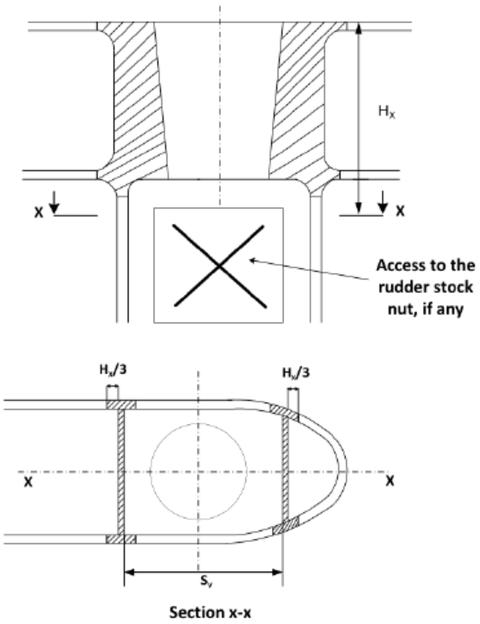
$$b = S_V + 2 \cdot \frac{H_X}{3}, \qquad m$$

where:

S_V = spacing between the two vertical webs, in m (see Figure 4.3.1)

4.3.8 Where openings for access to the rudder stock nut are not closed by a full penetration welded plate, they are to be deducted.

Figure 4.3.1: Cross-section of the connection between rudder blade structure and rudder stock housing



4.3.9 The thickness of the horizontal web plates connected to the solid parts, in mm, as well as that of the rudder blade plating between these webs, is to be not less than the greater of the following values:

$$t_H = 1{,}2 \cdot t\,, \qquad mm$$

$$t_H = 0{,}045 \cdot {d_s}^2/S_H\,, \qquad mm$$

Where:

t = as defined in 4.2.1

d_s = diameter, in mm, to be taken equal to:

= d_c, as per 3.2.3, for the solid part housing the rudder stock

= d_p, as per 6.1.1, for the solid part housing the pintle

S_H = spacing between the two horizontal web plates, in mm

4.3.10 The increased thickness of the horizontal webs is to extend fore and aft of the solid part at least to the next vertical web.

4.3.11 The thickness of the vertical web plates welded to the solid part where the rudder stock is housed as well as the thickness of the rudder side plating under this solid part is to be not less than the values obtained, in mm, from Table 4.3.1.

Table 4.3.1: Thickness of side plating and vertical web plates

Type of rudder	Thickness of vertical web plates, in mm		Thickness of rudder plating, in mm	
	Rudder blade without opening	Rudder blade with opening	Rudder blade without opening	Area with opening
Rudder supported by sole piece	1.2 t	1.6 t	1.2 t	1.4 t
Semi-spade and spade rudders	1.4 t	2.0 t	1.3 t	1.6 t

Where:

t = thickness of the rudder plating, in mm, as defined in 4.2.

4.4 Single plate rudders

4.4.1 Main piece diameter
The main piece diameter is calculated according to 3.1 and 3.2.3 respectively. For spade rudders the lower third may taper down to 0,75 times stock diameter.

4.4.2 Blade thickness
The blade thickness is not to be less than:

$$t_b = 1{,}5 \cdot s \cdot V \cdot \sqrt{k} + 2{,}5\,, mm$$

Where:

s= spacing of stiffening arms, not to exceed 1 m, m;

V= speed, see 2.1.1, knots.

k= material factor for the rudder plating as given in 1.3.1.

4.4.3 Arms
The thickness of the arms is not to be less than the blade thickness:

$$t_a = t_b\,,\ \text{mm}$$

The section modulus is not to be less than:

$$Z_a = 0{,}5 \cdot s \cdot C_1^2 \cdot V^2 \cdot k, \ \text{cm}^3$$

where:

C_1= horizontal distance from the aft edge of the rudder to the centerline of the rudder stock, m

k= material factor for the rudder plating as given in 1.3.1.

For higher tensile steels the material factor according to Part 3, Chapter 5, SECTION 3, 3.5 is to be used correspondingly.

SECTION 5 Rudder stock couplings

5.1 Horizontal flange couplings

5.1.1 The diameter of the coupling bolts is not to be less than:

$$d_b = 0.62 \cdot \sqrt{d^3 \cdot K_b \ / \ n \cdot e_m \cdot K_s}$$

Where:

d= stock diameter, the greater of the diameters dt or dc according to 3.1 and 3.2.3, mm.

n= total number of bolts, which is not to be less than 6.

e_m= mean distance of the bolt axes from the centre of the bolt system, mm.

K_s = material factor for the stock as given in 1.3.1.

K_b = material factor for the bolts as given in 1.3.1.

5.1.2 The thickness of the coupling flanges is not to be less than determined by the following formulae:

$$t_f = d_b \cdot \sqrt{K_f / K_b}$$

where:

K_f = material factor for flange as given in 1.3.1.

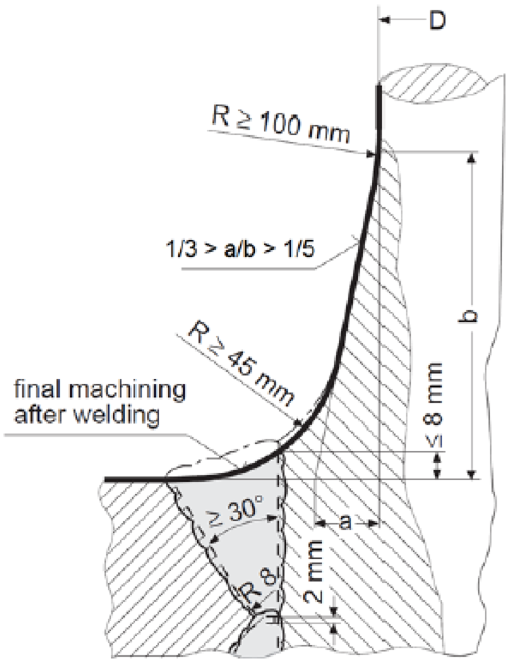
t_{fmin}= 0,9 $\cdot$ d_b

d_b= bolt diameter calculated for a number of bolts not exceeding 8.

5.1.3 The width of material outside the bolt holes between the perimeter of the bolt holes and the perimeter of the flange is not to be less than $0{,}67 \cdot d_b$.

5.1.4 The welded joint between the rudder stock and the flange is to be made in accordance with Figure 5.1.1 or equivalent.

Figure 5.1.1: Welded joint between rudder stock and coupling flange



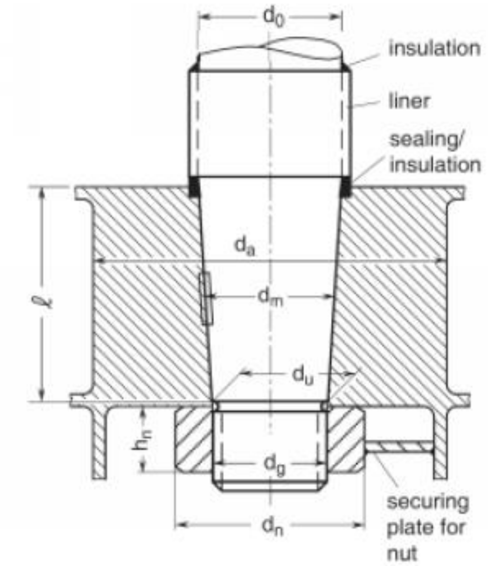
5.1.5 Coupling bolts are to be fitted bolts and their nuts are to be locked effectively.

5.2 Cone couplings with key

5.2.1 Tapering and coupling length

Cone couplings without hydraulic arrangements for mounting and dismounting the coupling should have a taper on diameter of 1:8-1:12 and be secured by a slugging nut.

Figure 5.2.1: Cone coupling with key



taper = (d_0 – d_u) / l

5.2.2 The cone coupling is to be secured by a slugging nut. The nut is to be secured, e.g. by a securing plate.

5.2.3 The cone shapes are to fit exactly. The coupling length l is to be, in general, not less than 1.5 d_0.

5.2.4 Dimensions of key

For couplings between stock and rudder a key is to be provided, the shear area of which, in cm^2, is not to be less than:

$$\alpha_s = \frac{17{,}55 \cdot Q_F}{d_k \cdot \sigma_{F1}}$$

Where:

Q_F = design yield moment of rudder stock, in Nm

$$Q_F = 0{,}02664 \cdot \frac{{d_t}^3}{k}$$

Where the actual diameter d_{ta} is greater than the calculated diameter d_t, the diameter d_{ta} is to be used. However, d_{ta} applied to the above formula need not be taken greater than 1,145 d_t.

d_t = stock diameter, in mm, according to 3.1.1.

k= material factor for the rudder plating as given in 1.3.1.

d_k= mean diameter of the conical part of the rudder stock, in mm, at the key

σ_{F1} = minimum yield stress of the key material, in N/mm^2

The effective surface area, in cm^2, of the key (without rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$\alpha_k = \frac{5 \cdot Q_F}{d_k \cdot \sigma_{F2}}$$

Where:

σ_{F2} = minimum yield stress of the key, stock or coupling material, in N/mm^2, whichever is Less.

5.2.5 The dimensions of the slugging nut are to be as follows (see Figure 5.2.1):

- external thread diameter: $d_g \geq 0,65\ d_o$
- height: $h_n \geq 0,6\ d_g$
- outer diameter: $d_n \geq 1,2\ d_u$, or $1,5\ d_g$ whichever is the greater.

5.2.6 Push up

It is to be proved that 50% of the design yield moment is solely transmitted by friction in the cone couplings. This can be done by calculating the required push-up pressure and push-up length according to 5.3.2 and 5.3.3 for a torsional moment Q'_F = 0,5 Q_F.

5.2.7 Notwithstanding the requirements in 5.2.2 and 5.2.4, where a key is fitted to the coupling between stock and rudder and it is considered that the entire rudder torque is transmitted by the key at the couplings, the scantlings of the key as well as the push-up force and push-up length are to be at the discretion of the Society.

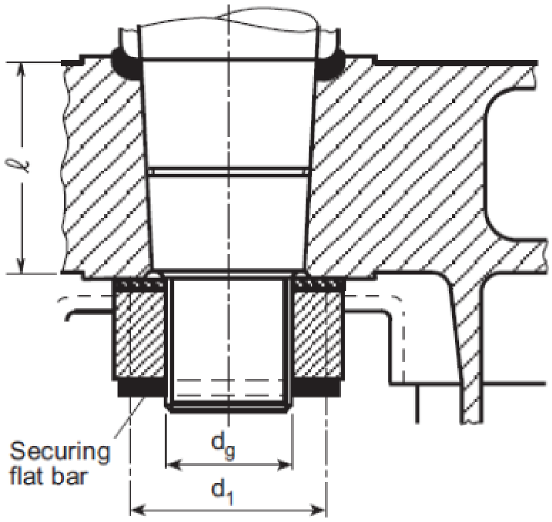
5.3 Cone couplings with special arrangements for mounting and dismounting the couplings

5.3.1 Where the stock diameter exceeds 200 mm, the press fit is recommended to be effected by a hydraulic pressure connection. In such cases the cone is to be more slender, c≈1:12 to ≈1:20.

In case of hydraulic pressure connections the nut is to be effectively secured against the rudder stock or the pintle.

For the safe transmission of the torsional moment by the coupling between rudder stock and rudder body the push-up pressure and the push-up length are to be determined according to 5.3.2 and 5.3.3 respectively.

Figure 5.3.1: Cone coupling without key



5.3.2 Push-up pressure

The push-up pressure is not to be less than the greater of the two following values:

$$p_{req1} = \frac{2 \cdot Q_F}{{d_m}^2 \cdot l \cdot \pi \cdot \mu_o} \cdot 10^3, \text{N/mm}^2$$

$$p_{req2} = \frac{6 \cdot M_b}{l^2 \cdot d_m} \cdot 10^3, \text{N/mm}^2$$

where:

Q_F = design yield moment of rudder stock, as defined in 5.2.4, in Nm

d_m = mean cone diameter in mm, see Figure 5.2.1.

l = cone length in mm

μ_o = frictional coefficient, equal to 0.15

M_b = bending moment in the cone coupling (e.g. in case of spade rudders), in Nm

It has to be proved by the designer that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure, in N/mm², is to be determined by the following formula:

$$p_{perm} = \frac{0{,}95 \cdot R_{eH} \cdot (1 - \alpha^2)}{\sqrt{3 + \alpha^4}} - p_b \text{ , N/mm}^2$$

where:

R_{eH} = minimum yield stress of the material of the gudgeon in N/mm²

$\alpha = \frac{d_m}{d_a}$

d_m= diameter, in mm, see Figure 5.2.1

d_a= outer diameter of the gudgeon, in mm, see Figure 5.2.1

The outer diameter of the gudgeon in mm shall not be less than 1.25 d_o, with d_o defined in FFigure 5.2.1.

5.3.3 Push-up length
The push-up length Δ_l, in mm, Δ_l is to comply with the following formula:

$$\Delta_{l1} \leq \Delta_l \leq \Delta_{l2}$$

Where:

$$\Delta_{l1} = \frac{p_{req} \cdot d_m}{E \cdot \left(\frac{1 - a^2}{2}\right) \cdot c} + \frac{0{,}8 \cdot R_{tm}}{c}, \qquad mm$$

$$\Delta_{l2} = \frac{p_{perm} \cdot d_m}{E \cdot \left(\frac{1 - a^2}{2}\right) \cdot c} + \frac{0{,}8 \cdot R_{tm}}{c}, \qquad mm$$

R_{tm} = mean roughness, in mm taken equal to 0,01

c = taper on diameter defined in 5.2.1

Note: In case of hydraulic pressure connections the required push-up force P_e, in N, for the cone may be determined by the following formula:

$$P_e = p_{req} \cdot d_m \cdot l \cdot \pi \cdot \left(\frac{c}{2} + 0{,}02\right)$$

The value 0,02 is a reference for the friction coefficient using oil pressure. It varies and depends on the mechanical treatment and roughness of the details to be fixed. Where due to the fitting procedure a partial push-up effect caused by the rudder weight is given, this may be taken into account when fixing the required push-up length, subject to approval by the Society.

5.4 Vertical flange couplings

5.4.1 The diameter of the coupling bolts is not to be less than:

$$d_b = \frac{0{,}81 \cdot d}{\sqrt{n}} \cdot \sqrt{\frac{K_b}{K_s}}, \qquad mm$$

where:

d= stock diameter in way of coupling flange

n= total number of bolts, which is not to be less than 8

$K_b =$ material factor for bolts as given in 1.3.1.

K_s= material factor for stock as given in 1.3.1.

5.4.2 The first moment of area of the bolts about the centre of the coupling, m, must be at least:

$$m = 0{,}00043 \cdot d^3, \qquad cm^3$$

The thickness of the coupling flanges must be at least equal to the bolt diameter, and the width of the flange material between the perimeter of the bolt holes and the perimeter of the flange must be greater than or equal to 0,67·d_b.

5.4.3 Coupling bolts are to be fitted bolts and their nuts are to be locked effectively.

SECTION 6 PINTLES

6.1 General

6.1.1 Pintles are to have a conical attachment to the gudgeons with a taper on diameter not greater than:

- 1:8-1:12 for keyed and other manually assembled pintles applying locking by slugging nut,
- 1:12-1:20 on diameter for pintles mounted with oil injection and hydraulic nut.

The length of the pintle housing in the gudgeon is not to be less than the maximum pintle diameter:

$$d_b = 0.35 \cdot \sqrt{B \cdot k_p}$$

Where:

B= the relevant bearing force and kp is the material factor as given in 1.3.1.

6.1.2 The minimum dimensions of threads and nuts are to be determined according to 5.2.3.

6.1.3 Push-up pressure for pintle
The required push-up pressure for pintle, in N/mm², is to be determined by the following formula:

$$p_{req} = 0{,}4\, \frac{B_1 \cdot d_0}{{d_m}^2 \cdot l}, \quad \mathrm{N/mm^2}$$

where:

B_1= Supporting force in the pintle, in N

d_0 = Pintle diameter, in mm, see Figure 5.2.1

The push-up length is to be calculated similarly as in 5.3.3, using required push-up pressure and properties for the pintle.

6.1.4 Pintle housing
The length of the pintle housing in the gudgeon is not to be less than the pintle diameter dp. dp is to be measured on the outside of liners.

The thickness of the pintle housing is not to be less than 0.25 dp

SECTION 7 Bearings

7.1 Rudder stock, shaft and pintle bearings

7.1.1 Minimum bearing surface
An adequate lubrication is to be ensured. The bearing surface A_b (defined as the projected area: length x outer diameter of liner) is not to be less than:

$$A_b = P/q_a , \ \mathrm{mm}^2$$

where:

P= reaction force in bearing as determined in 3.2.2, N

q_a = allowable surface pressure according to the table below.

The maximum surface pressure q_a for the various combinations is to be taken as:

Table 7.1.1: allowable surface pressure

Bearing material	**q_a N/mm²**
Lignum vitae	2,5
White metal, oil lubricated	4,5
Synthetic material with hardness between 60 and 70	5,5[4)]
Steel [2)] and bronze and hot-pressed bronze-graphite materials	7,0

NOTES:

1 Indentation hardness test at 23°C and with 50% moisture, according to a recognized standard.
2 Synthetic bearing materials to be of approved type.
3 Stainless and wear-resistant steel in an approved combination with stock liner.
4 Higher values than given in the table may be taken in accordance with makers' specifications if they are verified by tests.
5 Surface pressures exceeding 5,5 N/mm^2 may be accepted in accordance with bearing manufacturer's specification and tests, but in no case more than 10 N/mm^2.

7.1.2 Length of bearings

The length/diameter ratio of the bearing surface is not to be greater than 1,2.

The bearing length L_p of the pintle is to be such that

$$D_p \le L_p \le 1{,}2\, D_p$$

Where:

D_p = Actual pintle diameter measured on the outside of liners.

7.1.3 Bearing clearances

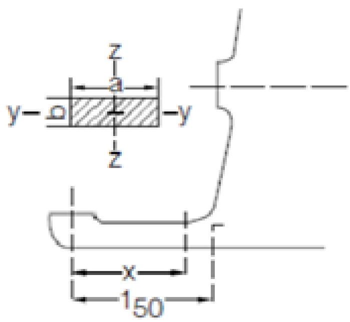
With metal bearings clearances should not be less than d_b/1000 + 1,0 mm on the diameter. If non-metallic bearing material is applied, the bearing clearance is to be specially determined considering the material's swelling and thermal expansion properties. This clearance in no way is to be taken less than 1,5 mm on bearing diameter unless a smaller clearance is supported by the manufacturer's recommendation and there is documented evidence of satisfactory service history with a reduced clearance.

SECTION 8 Sole piece and rudder horns

8.1 Strength of sole pieces and rudder horns

8.1.1 Sole piece

Figure 8.1.1:



The section modulus around the vertical (z)-axis is not to be less than:

$$Z_z = M_b \frac{K}{80}, \quad cm^3$$

The section modulus around the transverse (y)-axis is not to be less than:

$$Z_y = Z_z \cdot 0{,}5, \quad cm^3$$

The sectional area is not to be less than:

$$As = B_1\, k/48, \ mm^2$$

Where:

k= material factor as given in 1.3.1.

8.1.2 Equivalent stress

At no section within the length l_{50} the equivalent stress is to exceed $^{115}/_{k}$, $^{N}/_{mm^2}$. The equivalent stress is to be determined by the following formula:

$$\sigma_c = \sqrt{\sigma_b{}^2 + 3\,\tau^2, \qquad {}^{N}/_{mm^2}}$$

where:

σ_b= M_b/Z_z (x), N/mm²

τ= B_1 /As, N/mm²

M_b= bending moment at the section considered, Nm

M_b= B_1 x, Nm

M_{bmax}= B_1 l_{50}, Nm

B_1= supporting force in the pintle bearing, N (normally $B_1 = C_R/2$).

8.2 Rudder horn

8.2.1 When the connection between the rudder horn and the hull structure is designed as a curved transition into the hull plating, special consideration should be given to the effectiveness of the rudder horn plate in bending and to the stresses in the transverse web plates.

The loads on the rudder horn are as follows:

M_b= bending moment = $B_1 \cdot z$, Nm

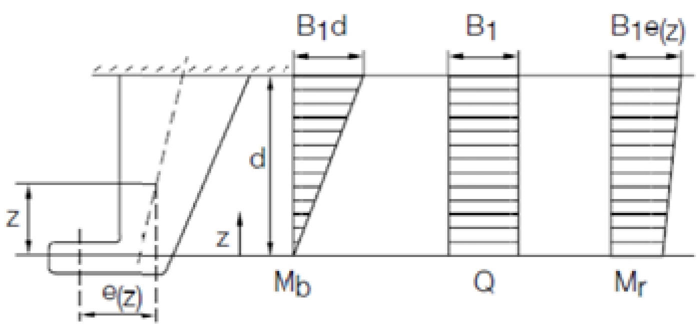
M_{bmax}= $B_1 \cdot d$, Nm

q= shear force = B_1, N

$M_T(z)$=torsional moment = $B_1 \cdot e(z)$, Nm

see Figure 8.2.1 below:

Figure 8.2.1:



An estimate for B_1 is:

$$B_1 = \frac{C_R \cdot b}{(l_{20} + l_{30})}, \quad N$$

Where:

b, l_{20} and l_{30}, see SECTION 9.

The section modulus around the horizontal x-axis is not to be less than:

$$Z_x = M_b \frac{k}{67}, \quad cm^3$$

The shear stress is not to be larger than:

$$\tau = {}^{48}/_{k}\ , \qquad {}^{N}/_{mm^2}$$

8.2.2 Equivalent stress

At no section within the length d the equivalent stress is to exceed ${}^{120}/_{k}$, ${}^{N}/_{mm^2}$. The equivalent stress is to be calculated by the following formula:

$$\sigma_c = \sqrt{\sigma_b{}^2 + 3\,(\tau^2 + \tau_t{}^2\,),} \qquad {}^{N}/_{mm^2}$$

$$\sigma_b = M_b/Z_x, \quad {}^{N}/_{mm^2}$$

$$\tau = {}^{B_1}/_{A_{h,}} \qquad {}^{N}/_{mm^2}$$

$$\tau_t = M_\tau\ 10^3\ /\ 2\ \cdot\ A_T\ \cdot\ t_h, \qquad {}^{N}/_{mm^2}$$

Where:

A_h= effective shear area of rudder horn in y-direction mm².

A_T = area in the horizontal section enclosed by the rudder horn, mm²

t_h= plate thickness of rudder horn, mm

k= material factor as given in 1.3.1.

8.2.3 Rudder horn plating

The thickness of the rudder horn side plating is not to be less than:

$$t = 2{,}4\ \cdot\ \sqrt{L\ \cdot k}$$

Where:

L= Rule length as defined in Part 3, Chapter 2, 1.2.2,

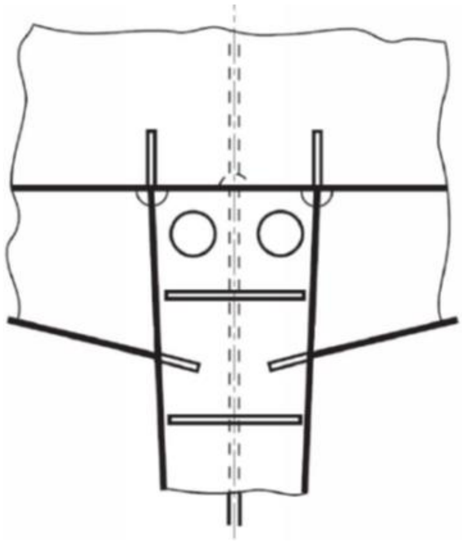
k= material factor as given in 1.3.1.

8.2.4 Welding and connection to hull structure

The rudder horn plating is to be effectively connected to the aft ship structure, e.g. by connecting the plating to side shell and transverse/ longitudinal girders, in order to achieve a proper transmission of forces, see Figure 8.2.2.

Brackets or stringer are to be fitted internally in horn, in line with outside shell plate, as shown in Figure 8.2.2.

Figure 8.2.2:



Transverse webs of the rudder horn are to be led into the hull up to the next deck in a sufficient number.

Strengthened plate floors are to be fitted in line with the transverse webs in order to achieve a sufficient connection with the hull.

The center line bulkhead (wash-bulkhead) in the after peak is to be connected to the rudder horn.

Scallops are to be avoided in way of the connection between transverse webs and shell plating.

The weld at the connection between the rudder horn plating and the side shell is to be full penetration. The welding radius is to be as large as practicable and may be obtained by grinding.

8.3 Rudder trunk

8.3.1 Materials, welding and connection to hull
This requirement applies to both trunk configurations (extending or not below stern frame).

The steel used for the rudder trunk is to be of weldable quality, with a carbon content not exceeding 0.23% on ladle analysis or a carbon equivalent CEQ not exceeding 0.41%.

The weld at the connection between the rudder trunk and the shell or the bottom of the skeg is to be full penetration.

The fillet shoulder radius r, in mm (see Figure 8.3.1) is to be as large as practicable and to comply with the following formulae:

$r = 60\ mm$ when $\sigma \geq 40/k$, N/mm^2

$r = 0{,}1\ d_c\ \ mm$ without being less than 30 mm when $\sigma \geq 40/k$, N/mm^2

Where:

d_c = rudder stock diameter axis defined in 3.2.3.

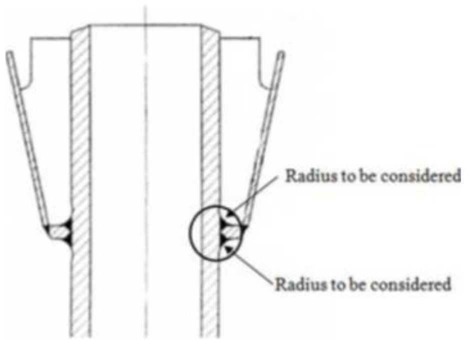
σ= bending stress in the rudder trunk in N/mm^2.

k = material factor as given in 1.3.1.

The radius may be obtained by grinding. If disk grinding is carried out, score marks are to be avoided in the direction of the weld. The radius is to be checked with a template for accuracy. Four profiles at least are to be checked. A report is to be submitted to the Surveyor.

Rudder trunks comprising of materials other than steel are to be specially considered by the Society.

Figure 8.3.1:



8.3.2 Scantlings
Where the rudder stock is arranged in a trunk in such a way that the trunk is stressed by forces due to rudder action, the scantlings of the trunk are to be such that:

- the equivalent stress due to bending and shear does not exceed 0.35 σ_F ,
- the bending stress on welded rudder trunk is to be in compliance with the following formula:

$$\sigma \leq {}^{80}/_{k} \,, \qquad {}^{N}/_{mm^2}$$

Where:

σ= bending stress in the rudder trunk, as defined in 8.3.1.

k = material factor for the rudder trunk as given in 1.3.1 and not to be taken less than 0.7,

σ_F = yield stress (N/mm^2) of the material used

For calculation of bending stress, the span to be considered is the distance between the mid height of the lower rudder stock bearing and the point where the trunk is clamped into the shell or the bottom of the skeg.

8.4 Pintle housing

8.4.1 The bearing length L_p of the pintle is to be such that:

$$D_p \leq L_p \leq 1{,}2 \cdot D_p$$

The length of the pintle housing in the gudgeon is not to be less than the pintle diameter D_p. The thickness of the pintle housing is not to be less than $0{,}25 \cdot D_p$.

SECTION 9-Guidelines for calculation of bending moment and shear force distribution

9.1 General

The evaluation of bending moments, shear forces and support forces for the system rudder - rudder stock may be carried out for some basic rudder types as shown below.

9.2 Spade rudder

9.2.1 Data for the analysis

$l_{10} - l_{30}$ = Lengths of the individual girders of the system in m

$I_{10} - I_{30}$ = Moments of inertia of these girders in cm^4

Load of rudder body:

$$P_R = \frac{C_R}{l_{10} \cdot 10^3}, \quad kN/m$$

9.2.2 Moments and forces

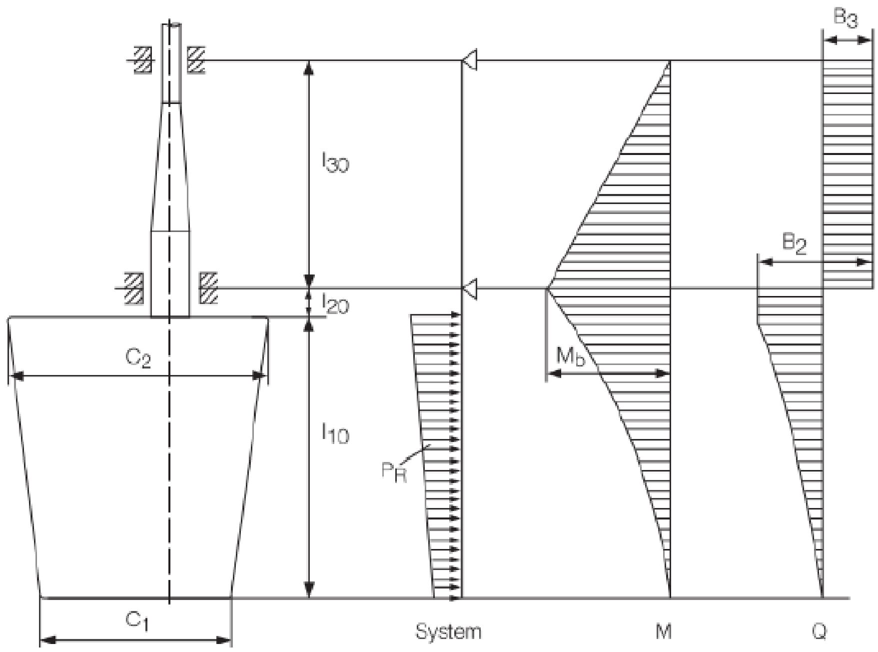
The moments and forces may be determined by the following formulae:

$$M_b = C_R \cdot \left(l_{20} + \left(l_{10}(2 \cdot c_1 + c_2)/3 \ (c_1 + c_2)\right)\right), \text{ Nm}$$

$$B_3 = \frac{M_b}{l_{30}}, \quad N$$

$$B_2 = C_R + B_3, \quad N$$

Figure 9.2.1: Spade rudder



9.3 Spade rudder with trunk

9.3.1 Data for the analysis

l_{10} – l_{30} = Lengths of the individual girders of the system in m

I_{10} – I_{30} = Moments of inertia of these girders in cm4

Load of rudder body:

$$P_R = \frac{C_R}{(l_{10} + l_{20}) \cdot 10^3}, \quad kN/m$$

9.3.2 Moments and forces

For spade rudders with rudders trunks the moments, in Nm, and forces, in N, may be determined by the greatest of the following values:

$$M_{CR1} = C_{R1} \cdot (CG_{1Z} - l_{10})$$

$$M_{CR2} = C_{R2} \cdot (l_{10} - CG_{2Z})$$

Where:

C_{R1} = Rudder force over the rudder blade area A_1

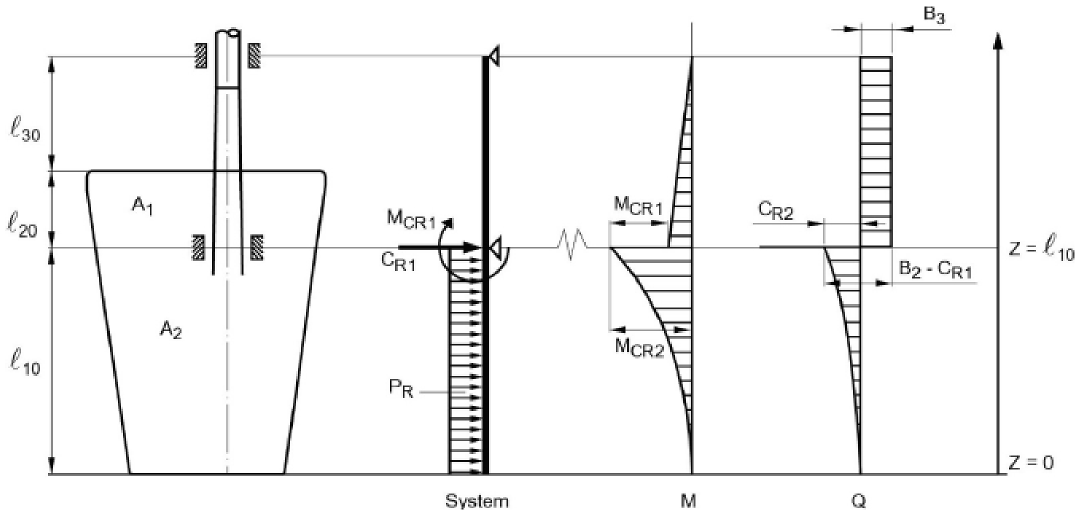
C_{R2} = Rudder force over the rudder blade area A_2
CG_{1Z} = Vertical position of the centre of gravity of the rudder blade area A_1 from base
CG_{2Z} = Vertical position of the centre of gravity of the rudder blade area A_2 from base

$$C_R = C_{R1} + C_{R2}$$

$$B_3 = \frac{M_{CR2} - M_{CR1}}{(l_{20} + l_{30})}$$

$$B_2 = C_R + B_3$$

Figure 9.3.1: Spade rudder with trunk



9.4 Rudder supported by sole piece

9.4.1 Data for the analysis

l_{10} – l_{50} = Lengths of the individual girders of the system in m

I_{10} - I_{50} = Moments of inertia of these girders in cm^4

For rudders supported by a sole piece the length ℓ_{20} is the distance between lower edge of rudder body and centre of sole piece and I20 the moment of inertia of the pintle in the sole piece.

I_{50} = moment of inertia of sole piece around the z-axis cm^4;
l_{50} = effective length of sole piece in m;

Load of rudder body:

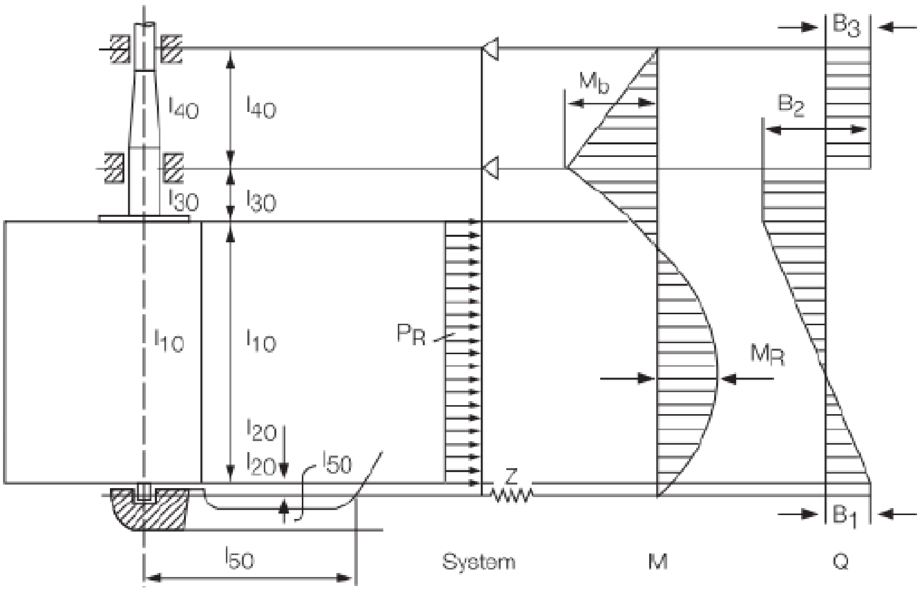
$$P_R = \frac{C_R}{l_{10} \cdot 10^3}, \quad kN/m$$

Z = spring constant of support in the sole piece

$$Z = \frac{6{,}18 \cdot I_{50}}{{l_{50}}^3}, \quad kN/m$$

9.4.2 Moments and forces
Moments and shear forces are indicated in Figure 9.4.1

Figure 9.4.1: Rudder supported by sole piece



9.5 Semi spade rudder with one elastic support

9.5.1 Data for the analysis

$l_{10} - l_{50}$ = Lengths of the individual girders of the system in m

$I_{10} - I_{50}$ = Moments of inertia of these girders in cm^4

Z = spring constant of support in the rudder horn

$Z = \frac{1}{f_b + f_t}, \quad kN/m$ for the support in the rudder horn (Figure 9.5.1)

f_b = unit displacement of rudder horn in [m] due to a unit force of 1 kN acting in the centre of Support

$f_b = 1{,}3\, d^3 \frac{1}{6{,}18\, I_n}, m/kN$ (guidance value)

I_n = moment of inertia of rudder horn around the x-axis in cm^4 (see also Figure 9.5.1)

f_t = unit displacement due to torsion

$$f_t = d_e{}^2 \sum u_i / t_i / (3{,}14 \cdot 10^8 \cdot F_T{}^2), \quad m/kN$$

F_T = mean sectional area of rudder horn in m^2
u_i = breadth in mm of the individual plates forming the mean horn sectional area
t_i = thickness within the individual breadth u_i in mm
d = Height of the rudder horn, in m, defined in Figure 9.5.1. This value is measured downwards
from the upper rudder horn end, at the point of curvature transition, to the mid-line of the lower rudder horn pintle
e = distance as defined in Figure 9.5.2

Load of rudder body:

$$P_{R10} = \frac{C_{R2}}{l_{10} \cdot 10^3}, \quad kN/m$$

$$P_{R20} = \frac{C_{R1}}{l_{20} \cdot 10^3}, \quad kN/m$$

For C_R, C_{R1}, C_{R2} see 9.2

9.5.2 Moments and forces
Moments and shear forces are indicated in Figure 9.5.1.

9.5.3 Rudder horn
The loads on the rudder horn are as follows:

M_b = bending moment = $B_1\, z,\ \ Nm,$

$M_{bmax} = B_1\, d,\ \ Nm$

q = shear force $= B_1,\ \ N$

$M_T(z)$ = torsional moment = $B_1\, e\,(Z),\ \ Nm$

An estimate for B_1 is:

$$B_1 = \frac{C_R\, b}{(l_{20} + l_{30})}, \quad N$$

Figure 9.5.1: Semi spade rudder with one elastic support

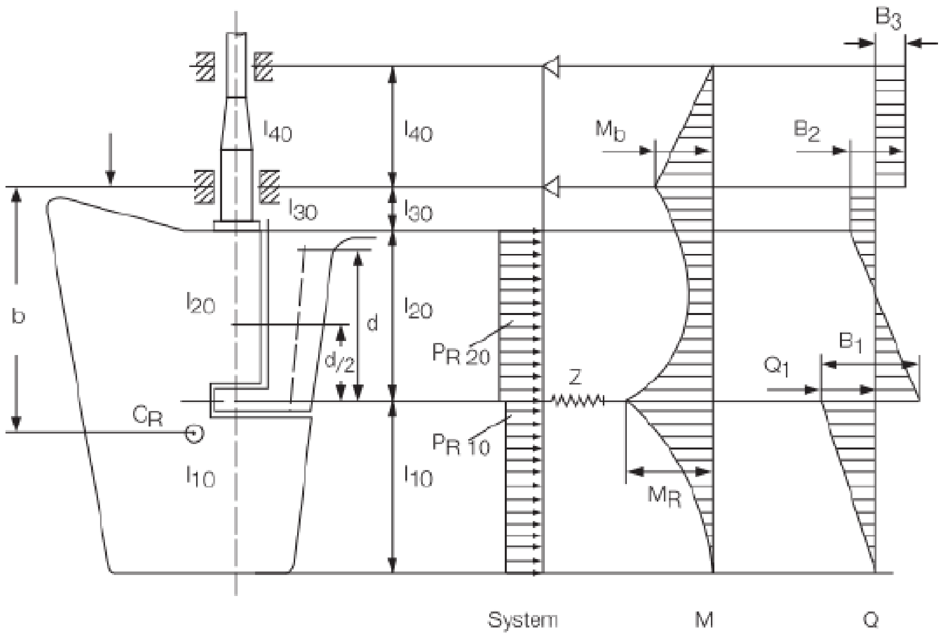
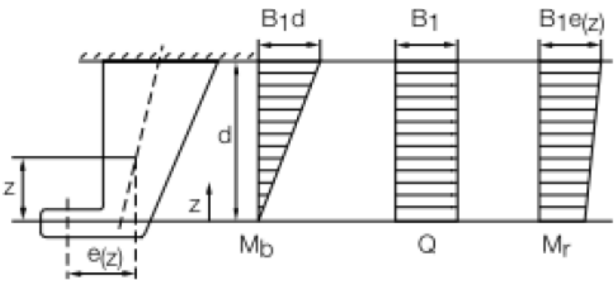


Figure 9.5.2: Semi spade rudder with one elastic support



9.6 Semi spade rudder with 2-conjugate elastic support

9.6.1 Data for the analysis

K_{11}, K_{22}, K_{12}: Rudder horn compliance constants calculated for rudder horn with 2-conjugate elastic supports (Figure 9.10.1). The 2-conjugate elastic supports are defined in terms of horizontal displacements, yi, by the following equations:

- at the lower rudder horn bearing:

$$y_1 = -K_{12}\, B_2 - K_{22}\, B_1$$

- at the upper rudder horn bearing:

$$y_2 = -K_{11}\, B_2 - K_{12}\, B_1$$

where:

y_1, y_2 = Horizontal displacements, in m, at the lower and upper rudder horn bearings, respectively.

B_1, B_2 = Horizontal support forces, in kN, at the lower and upper rudder horn bearings, respectively.

K_{11}, K_{22}, K_{12} = Obtained, in m/kN, from the following formulae:

$$K_{11} = 1{,}3 \cdot \frac{\lambda^3}{3\,E\,J_{1h}} + \frac{e^2\,\lambda}{G\,J_{th}}$$

$$K_{22} = 1{,}3 \cdot \left[\frac{\lambda^3}{3\,E\,J_{1h}} + \frac{\lambda^2\,(d\ \ \lambda)}{2\,E\,J_{1h}}\right] + \frac{e^2\,\lambda}{G\,J_{th}}$$

$$K_{12} = 1{,}3 \cdot \left[\frac{\lambda^3}{3\,E\,J_{1h}} + \frac{\lambda^2\,(d\ \ \lambda)}{E\,J_{1h}} + \frac{\lambda\,(d\ \ \lambda)^2}{E\,J_{1h}} + \frac{(d\ \ \lambda)^3}{3\,E\,J_{2h}}\right] + \frac{e^2\,d}{G\,J_{th}}$$

d= Height of the rudder horn, in m, defined in Figure 9.10.1. This value is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the lower rudder horn pintle.

λ= Length, in m, as defined in Figure 9.10.1. This length is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the upper rudder horn bearing. For λ = 0, the above formulae converge to those of spring constant Z for a rudder horn with 1-elastic support, and assuming a hollow cross section for this part.

e = Rudder-horn torsion lever, in m, as defined in Figure 9.10.1 (value taken at z = d/2).

J_{1h} = Moment of inertia of rudder horn about the x axis, in m^4, for the region above the upper rudder horn bearing. Note that J_{1h} is an average value over the length λ (Figure 9.10.1).

J_{2h} = Moment of inertia of rudder horn about the x axis, in m^4, for the region between the upper and lower rudder horn bearings. Note that J_{2h} is an average value over the length d - λ (see Figure 9.10.1).

J_{th} = Torsional stiffness factor of the rudder horn, in m^4.

For any thin wall closed section:

$$J_{th} = \frac{4\,{F_T}^2}{\sum_i \frac{u_i}{t_i}}$$

Where:

F_T = Mean of areas enclosed by outer and inner boundaries of the thin walled section of rudder horn, in m^2.
u_i = Length, in mm, of the individual plates forming the mean horn sectional area.

t_i = Thickness, in mm, of the individual plates mentioned above.

Note that the J_{th} value is taken as an average value, valid over the rudder horn height.

Load of rudder body:

$$P_{R10} = \frac{C_{R2}}{l_{10}\, \cdot\, 10^3}\,, \quad kN/m$$

$$P_{R20} = \frac{C_{R1}}{l_{20}\, \cdot\, 10^3}\,, \quad kN/m$$

For C_R, C_{R1}, C_{R2} see 9.2

9.6.2 Moments and forces
Moments and shear forces are indicated in Figure 9.10.1.

9.7 Rudder horn bending moment

The bending moment acting on the generic section of the rudder horn is to be obtained, in Nm, from the following formulae:

- between the lower and upper supports provided by the rudder horn:

$$M_H = F_{A1}\, z$$

- above the rudder horn upper-support:

$$M_H = F_{A1}\, z + F_{A2}\,(z - d_{lu})$$

Where:

F_{A1} = Support force at the rudder horn lower-support, in N, to be obtained according to Figure 9.10.1, and taken equal to B_1.
F_{A2} = Support force at the rudder horn upper-support, in N, to be obtained according to Figure 9.10.1, and taken equal to B_2.
z= Distance, in m, defined Figure 9.10.2, to be taken less than the distance d, in m, defined in the same figure
d_{lu}= Distance, in m, between the rudder-horn lower and upper bearings (according to Figure 9.10.1, d_{lu} = d - λ).

9.8 Rudder horn shear force

The shear force Q_H acting on the generic section of the rudder horn is to be obtained, in N, from the following formulae:

- between the lower and upper rudder horn bearings:

$$Q_H = F_{A1}$$

- above the rudder horn upper-bearing:

$$Q_H = F_{A1} + F_{A2}$$

Where:

F_{A1}, F_{A2} = Support forces, in N.

The torque acting on the generic section of the rudder horn is to be obtained, in Nm, from the following formulae:

- between the lower and upper rudder horn bearings:

$$M_T = F_{A1}\, e_{(z)}$$

- above the rudder horn upper-bearing

$$M_T = F_{A1}\, e_{(z)} + F_{A2}\, e_{(z)}$$

where:

F_{A1}, F_{A2} = Support forces, in N.

$e_{(z)}$ = Torsion lever, in m, defined in Figure 9.10.2.

9.9 Rudder horn shear stress calculation

For a generic section of the rudder horn, located between its lower and upper bearings, the following stresses are to be calculated:

τ_s = Shear stress, in N/mm², to be obtained from the following formula:

$$\tau_s = \frac{F_{A1}}{A_H}$$

T_T = Torsional stress, in N/mm², to be obtained for hollow rudder horn from the following formula:

$$T_T = \frac{M_T\, 10^{-3}}{2\ F_T\ t_H}$$

For solid rudder horn, T_T is to be considered by the Society on a case by case basis.

For a generic section of the rudder horn, located in the region above its upper bearing, the following stresses are to be calculated:

τ_s = Shear stress, in N/mm², to be obtained from the following formula:

$$\tau_s = \frac{F_{A1} + F_{A2}}{A_H}$$

T_T = Torsional stress, in N/mm², to be obtained for hollow rudder horn from the following formula:

$$T_T = \frac{M_T\, 10^{-3}}{2\ F_T\ t_H}$$

For solid rudder horn, T_T is to be considered by the Society on a case by case basis where:

F_{A1}, F_{A2} = Support forces, in N.

A_H = Effective shear sectional area of the rudder horn, in mm², in y-direction;
M_T = Torque, in Nm;
F_T = Mean of areas enclosed by outer and inner boundaries of the thin walled section of rudder horn, in m²;
t_H = Plate thickness of rudder horn, in mm. For a given cross section of the rudder horn, the maximum value of T_T is obtained at the minimum value of t_H.

9.10 Rudder horn bending stress calculation

For the generic section of the rudder horn within the length d, the following stresses are to be calculated:

σ_B = Bending stress, in N/mm², to be obtained from the following formula:

$$\sigma_B = \frac{M_H}{W_X}$$

where:

M_H = Bending moment at the section considered, in Nm.
W_X = Section modulus, in cm³, around the X-axis (see Figure 6).

Figure 9.10.1: Semi spade rudder with 2-conjugate elastic support

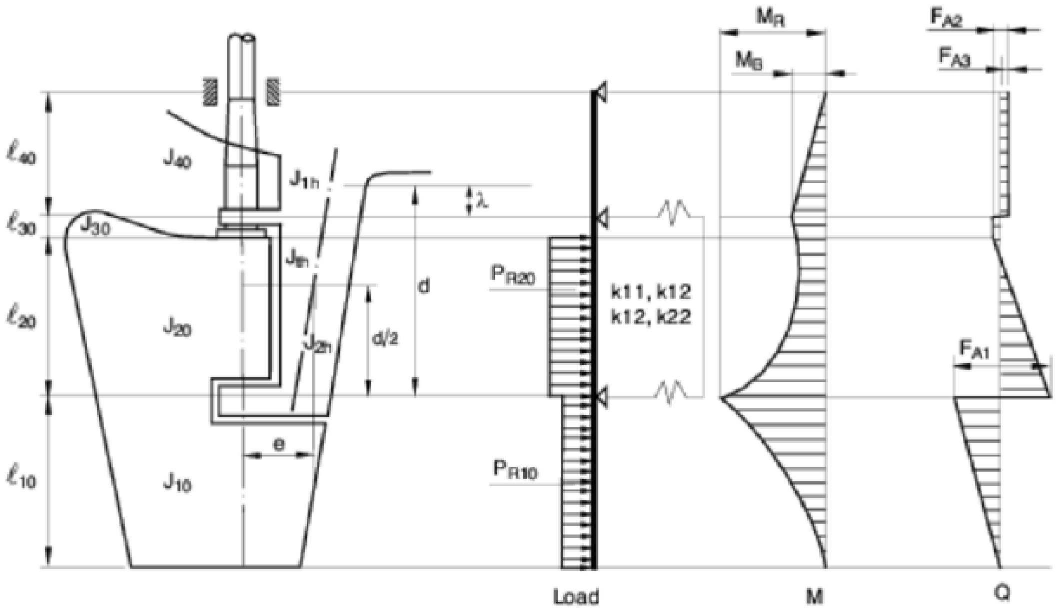
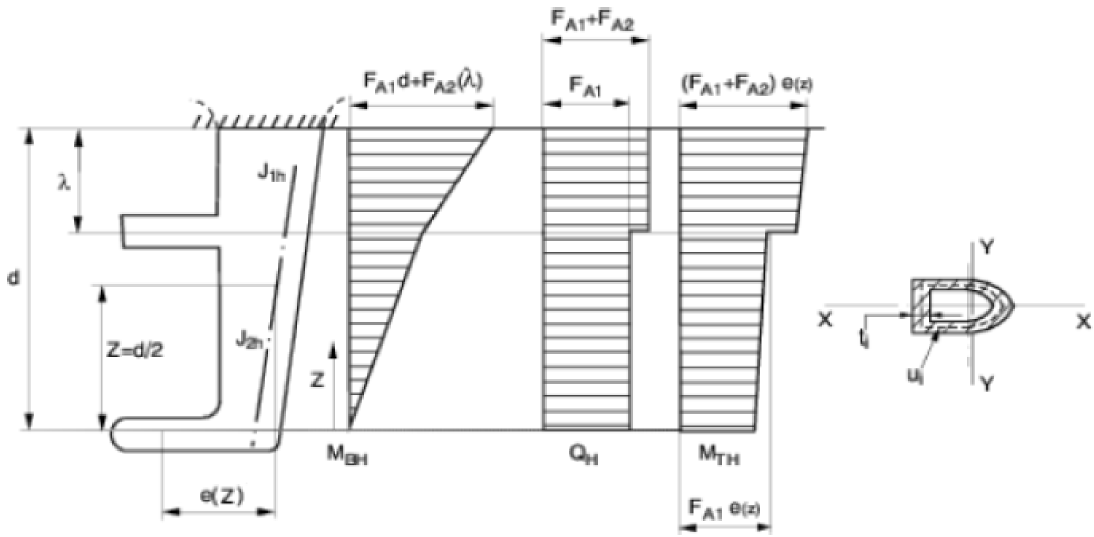


Figure 9.10.2: Semi spade rudder with 2-conjugate elastic support



SECTION 10 Shaft struts

10.1 Application

10.1.1 The requirements of this Section apply to struts of either V or I type.

10.1.2 Propeller shaft struts may be of V or I type. The thickness of the shaft barrel or boss is to be at least one-fourth the diameter of the tail shaft. The length of the strut barrel or boss is to be adequate to accommodate the propeller end bearings. The following equations are for struts having streamline cross-sectional shapes.

10.2 V Strut

10.2.1 The requirements for section modulus and inertia of each strut arm are in general to be in accordance with the following equations:

Section Modulus: $0.024 \cdot d^3$, mm^3

Moment of Inertia: $0.0044 \cdot d^4$, mm^4

Where:

d= required diameter of tail shaft according to Part 5, Chapter 5, in mm.

10.2.2 Where the included angle is less than 45 degrees the scantlings are to be specially considered.

10.3 I Strut

10.3.1 The requirements for section modulus and inertia of each strut arm are in general to be in accordance with the following:

Section Modulus: $0.068 \cdot d^3$, mm^3

Moment of Inertia: $0.018 \cdot d^4$, mm^4

Where:

d= required diameter of tail shaft according to Part 5, Chapter 5, in mm.

10.4 Strut length

10.4.1 The length of the longer leg of a V strut or the leg of an I strut, measured from the outside perimeter of the strut barrel or boss to the outside of the shell plating, is not to exceed 10.6 times the diameter of the tail shaft. Where this length is exceeded, the width and thickness of the strut are to be increased and the strut design will be given special consideration.

Rules and Regulations

for the

Classification and Construction of

SMALL CRAFTS

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Part 4 - Specialized Vessels

June 2019

CHAPTER 1 OFFSHORE SUPLY VESSELS

SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to ships which are specially designed for the service of offshore units and intended to have the service notation OFFSHORE SUPPLY VESSEL.

1.1.2 Unless otherwise mentioned in this Chapter, the requirements of Part 3 are applicable.

1.1.3 For offshore supply vessels the relevant requirements of the IMO Resoltuion A.469 (Xll) apply with regard to intact stability and damaged stability.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be made in accordance with the requirements of Part 3.

SECTION 3 Hull envelope plating

SECTION 3 Hull envelope plating

3.1 Side shell plating

3.1.1 The thickness of the side shell plating including the bilge strake is to be in accordance with the requirements of Part 3, but in no case is to be less than 9 mm.

3.1.2 Where the stern area is subjected to loads due to heavy cargo, sufficient strengthening is to be provided.

3.1.3 In exposed areas efficient fenders are to be fitted with adequate support behind them.

3.2 Deck plating

3.2.1 The thickness of the weather deck Is to be in accordance with the requirements of Part 3, but in no case is to be less than 8 mm. Additional local increases in scantlings may be required where specialized cargoes are likely to induce concentrated loads.

3.2.2 Stowracks are to be fitted on deck, for deck cargoes, and are to be effectively attached to the deck.

3.2.3 Small hatches, valve controls, ventilators, air pipes etc. are to be located in protected positions in order to avoid damage by cargo and to minimize the possibility of flooding of other spaces.

SECTION 4 Framing

4.1 Transverse framing system

4.1.1 The section modulus of the main and tween deck frames is to be increased by 25% above the values required by Part 3.

SECTION 5 Superstructures and deckhouses

5.1 Scantlings

5.1.1 The thickness of the side and end bulkhead plating of superstructures and deckhouses is to be increased by 1 mm above the thickness required by Part 3.

5.1.2 The section modulus of stiffeners is to be increased by 5% above the values required by Part 3.

SECTION 6 Access to spaces

6.1 Access to machinery spaces

6.1.1 Access to machinery spaces should, if possible, be arranged within the forecastle. Any access to the machinery space from the exposed cargo deck is to be provided with two weathertight closures.

6.1.2 Machinery space ventilators are to be located as high as is practicable above the deck and are to be fitted with spark arresters.

6.2 Access to spaces below the exposed cargo deck

6.2.1 Access to spaces below the exposed cargo deck shall preferably be from a position within or above the superstructure deck.

CHAPTER 2 TUGS

SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to ships which are specially designed for towing operations and intended to have the service notation TUG.

1.1.2 Unless otherwise mentioned in this Chapter, the requirements of Part 3 are applicable. The draught T used for the determination of scantlings is to be not less than 0.85 D.

1.2 Information required

1.2.1 In addition to the information specified in Part 3, the following plans are to be submitted for approval:

a. Towing hook.

b. Slip arrangement.

c.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be made in accordance with the requirements of Part 3.

SECTION 3 Bottom structure

3.1 General

3.1.1 The bottom structure is to be in accordance with the requirements of Part 3.

SECTION 4 Machinery casings

4.1 Exposed casings

4.1.1 The height of exposed machinery room casings is not to be less than 900 mm above the upper surface of the deck and are to be made watertight.

4.1.2 Stiffeners to exposed casings are to be connected to the deck or carried through.

4.2 Emergency exit

4.2.1 In the machinery room an emergency exit is to be provided, which can be used at extreme angles of heel and should be positioned as high as possible above the waterline and on or near the vessel's centreline.

4.2.2 The cover of the emergency exit, which is to have a weathertight closure, is to be capable of being opened easily from outside and inside. The axis of the cover is to run in the athwartship direction.

4.2.3 The coaming height is to be at least 600 mm above the upper surface of the deck.

SECTION 5 Towing arrangement

5.1 Towing hook

5.1.1 The towing hook is to be fitted as low as practicable in order to minimize heeling moments arising in normal working conditions.

5.1.2 The towing hook has to be fitted with a reliable slip arrangement which facilitates towline release, regardless of the angle of heel.

5.1.3 The slip arrangement should be operable from the bridge, as well as in the vicinity of the hook itself.

5.1.4 The towing arrangement should be tested to the Surveyor's satisfaction.

5.1.5 The breaking strength of the towing hook should generally be 50 per cent in excess of that of the towline.

SECTION 6 Fenders

6.1 General

6.1.1 A strong fender is to be provided to the ship's side at deck level extending all fore and aft.

SECTION 7 Equipment

7.1 Towlines

7.1.1 Towlines need not comply with the requirements of Part 3, but should be adequate for the tug's maximum bollard pull, with an appropriate factor of safety which is not to be taken less than 2.

SECTION 8 Procedural Instructions for Bollard Pull Test

8.1 Scope

At the Owners or Interested Parties request, tugs may be subjected to a bollard pull test and a surveyor may witness and certify the bollard pull performance testing. The purpose of the present procedural instructions is to describe the process for the bollard pull test as well as the conditions (environmental, vessel, trial site) in order to execute the bollard pull test.

8.2 References

- IMO Resolution A.765(18)
- IMO MSC/Circ.884
- WI4.1 'OPERATION OF THE OVERSEAS AUTHORITIES DEPT.', as amended
- WI4.2 'OPERATION OF THE NAVAL PROJECTS DEPT.', as amended
- 11-1.ΔΠ 'ΕΠΙΘΕΩΡΗΣΕΙΣ ΠΛΟΙΩΝ ΥΠΟ ΕΛΛΗΝΙΚΗ ΣΗΜΑΙΑ', as amended
- QP.5 'ADMINISTRATIVE DIVISION', as amended
- WI5.1 'FILING PROCESS', as amended
- QP7 'PAPERLESS OFFICE & ELECTRONIC RECORDS', as amended
- QP9 'TECHNICAL STAFF'S TRAINING PROCESS', as amended

8.3 Documentation and data to be submitted

Prior to the testing, a proposed test program shall be submitted.

The information that should be provided to the Organization:

- Application indicating the proposed place where the test will be executed

- Specification of the measuring equipment to be used during the test (type, number and location of load cells)
- Recording procedure of the measured quantities
- Test configuration
- Main particulars and dimensions of the examined tug
- Copy of the Ship Registry Certificate of the tug
- Documentation of all towing vessel's equipment (towing winch, breaking load of the main towing wire, etc.)
- Copy of previous bollard pull test certificate, if any
- Draft corresponding to the full load condition (maximum draft)
- Draft and trim corresponding to the bollard pull test condition
- Type of the main propulsion engine(s)
- Maximum continuous rating (MCR) and corresponding rpm
- Gearing ratio
- Propeller(s) characteristics (type, diameter, number of blades)
- Type of propeller duct, if any
- Service speed when not employed in operation
- Expected maximum bollard pull value

8.4 Trial site and characteristics

The bollard pull testing should be carried out at a site which affords sufficient sea space and depth, without any obstacles within a free distance.

The trial site should be equipped with an appropriate bollard of adequate strength located on the shore.

The length of the towline should not be less than 300 meters, measured between the stern of the vessel and the test bollard. A minimum length of twice the vessel length might be accepted.

The water depth at the test location should not be less than 20 meters within a radius of 100 meters of the vessel. If the water depth of 20 meters cannot be obtained at the test location, then a minimum water depth which is equal to twice the maximum draft of the vessel may be accepted. It should be noted that reduced water depth may adversely affect the test results.

The velocity of the current should not exceed the 0.5 m/s in any direction. If the current exceeds this value, the bollard pull test should be conducted at the discretion of the Surveyor in order the bollard pull results not to be affected.

The test should be performed with a wind speed not exceeding 5 m/s and in any case the wind speed shall not affect its execution.

The sea condition should be calm and shall not have any significant effect on the test.

Measurements of the current and wind velocity shall be taken in the presence of surveyor and provided to him by the tug Interested Parties or Owner's representative.

8.5 Vessel requirements

All draughts (forward, aft and mean) of the tug should be recorded.

The displacement should correspond to normal operation condition and in general is proposed to correspond to full ballast condition with half fuel capacity.

The tug shall be even keeled or trimmed by stern, with trim not exceeding the 2% of the vessel's length.

At masters responsibility, all deck equipment and fittings (e.g. towing winch and drum, hooks) used during the test should be in good condition and capable of sufficiently withstanding the load of the anticipated maximum bollard pull.

All machinery and deck equipment used in the test should be part of the tug's normal outfit.

At masters responsibility the propeller(s) used during the test should be the propeller(s) used when the tug is in normal service.

When measuring the Bollard Pull, the main engine(s) shall be run at the manufacturer's recommended MCR.

All auxiliary components, such as pumps, generators, etc., which are driven by the main engine(s) or propeller shaft(s) in normal operation should be connected during the test.

8.6 Instrumentation

The load cell used for the test should be provided with calibration reports or/and calibration certificates by laboratories recognized by the Organization provided that the last calibration was performed not more than 12 months before the test.

The accuracy of the load cell should be such that maximum deviation from the anticipated bollard pull value is not more than 2% within a temperature range of 0°C and 40°C.

Associated to the load cell, instrument(s) capable of reading the tug pull and recording the values as a function of time in numerical and if possible in graphical form, should be provided. The load cell should be fitted between the towline used in the test and the shore bollard.

An efficient communication system between the tug and the shore personnel monitoring the bollard pull measurements should be established.

The arrangement of the towline, bollard and load cell should be horizontal. Otherwise, the vertical angle of this geometrical axis should be measured and used to obtain the actual horizontal pull.

8.7 Testing measurements

During the initial phase of the test, the main engine(s) of the tug should be operated so as to keep the towline in minimum tension, in order the tug to be located in the proper position for the measurement of the pull.

The revolutions of the main engine(s) are gradually increased until the pull measurements to be fairly constant with the main engine at maximum continuous power.

During the transient period of the accelerated engine revolutions, the maximum Bollard Pull value is usually achieved, followed by the steady state of constant pull measurements.

By achieving the steady state, the steady (static) bollard pull (BP) will be estimated as the average of the pull values over a minimum of 10 minutes duration.

During the phase where the pull measurements should be kept constant, the tug may have a tendency to yaw, thus the rudder action may be necessary in order to keep the tug in the proper position. If the difference in pull measurements during these corrective actions exceeds the 10% of the mean value, then these time durations will be ignored.

During the time where steady state pull measurements are recorded, the engine revolutions and the associated power generated should be also recorded in the presence of the Surveyor.

Any auxiliary equipment connected to the main engine(s) or the propeller shaft(s) during the test, will be noted in the *Report for the Bollard Pull Test*.

8.8 Towing hook and quick release

The towing hook shall be fitted with an adequate device guaranteeing slipping, i.e. emergency release, of the towline in case of an emergency. Slipping shall be possible from the bridge as well as from at least one other place in the vicinity of the hook itself, from where in both cases the hook can be easily seen.

The towing hook shall be equipped with a mechanical, hydraulic or pneumatic quick release. The quick release shall be designed such as to guarantee that unintentional slipping is avoided.

Where a pneumatic or hydraulic quick release is used, a mechanical quick release shall be provided additionally.

8.9 Arrangements

The arrangements necessary for the conduction of the test is in the responsibility of the Owners or the Interested Parties.

As guidance, Table 1 presents the minimum requirements of the breaking load of the wire used in the towline according to IMO MSC/Circ. 884.

Table 1: Minimum documented breaking load of the wire used in the towline

Expected Steady Bollard Pull (BP) (tonnes)	Minimum documented breaking load of the wire used in the towline (tonnes)
< 40	3 * BP
40 - 90	(3.8 – BP / 50) * BP
> 90	2 * BP

8.10 Actions before, during and after the test

The Surveyor must be given full access to the tug and its equipment before, during and immediately following the test.

The test readings and measurements should be continuously and immediately available to the Surveyor.

Upon the completion of the test, the Surveyor should examine the good condition of the deck equipment used during the test

Upon the completion of the bollard pull test, the Surveyor completes a *Report for the Bollard Pull Test.*

Based upon the test result, a *Bollard Pull Test Certificate* will be issued.

Upon request, certification of BP recorded when running the engine at different situations (reduced revolutions or reduced number of engines) or reduced number of / different propellers can be given placing the appropriate note/s.

8.11 Training

The surveyor, who will perform this job, shall be trained and qualified in accordance with QP9, for performing class or statutory surveys in the relevant types of vessel.

8.12 Responsibility

The responsibility for the effective application of this procedure rests with the Surveyor(s) involved.

It is the responsibility of the department Coordinator involved, to ensure that, the Surveyor assigned to perform the work described in these procedural instructions, is proficient in all of its areas.

8.13 Quality records

The *Report for the Bollard Pull Test* described in these procedural instructions and the copies of the certificates issued / endorsed are considered as quality records and are treated in accordance to the quality processes QP5, WI5.1 and QP7.

CHAPTER 3 Barges and Pontoons

SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to manned or unmanned non-self-propelled ships defined as follows:

a. Barges for the carriage of dry cargoes in cargo holds.

b. Barges for the carriage of liquid cargoes in bulk.

c. Pontoons designed for the carriage of cargo on deck.

1.1.2 For barges carrying dry cargoes and for pontoons, unless otherwise mentioned in this Chapter, the requirements of Part 3 are applicable.

1.2 Definitions

1.2.1 For ships with swim ends, the length L may be measured to the outside surface of the rake plating at the summer load waterline.

1.2.2 Where swim ends are fitted both fore and aft, or where a swim end is arranged aft but no rudder is fitted, then L need not exceed 97% of the extreme length on the summer load waterline.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be made in accordance with the requirements of Part 3, but the midship section modulus may be 5% less than required according to Part 3.

2.1.2 The scantlings of the primary longitudinal members (strength deck, shell plating, deck longitudinals, bottom and side longitudinals) may be 5% less than required in Part 3.

2.1.3 Longitudinal strength calculations for the condition “Barge, fully loaded, at crane” are required, where barges are intended to be lifted on board ship by means of cranes. for this condition, the following stresses are permissible:

a. Bending stress $\sigma_b = 150$ N/mm².

b. Shear stress $\tau = 100$ N/mm².

SECTION 3 Hull envelope plating

3.1 Swim end plating

3.1.1 The bottom shell plating thickness is to be maintained up to the summer load waterline for the rake plating. Above this point, the thickness may be tapered to that of the side shell requirements from a point not less than 1 m above the load waterline.

SECTION 4 Bulkheads

4.1 Collision bulkhead

4.1.1 For barges and pontoons, the position of the collision bulkhead is to be determined according to Part 3.

4.1.2 Where in barges and pontoons the form and construction of their ends is identical, so that there is no determined fore or aft of the ship, a collision bulkhead is to be fitted at each end.

4.2 Hold watertight bulkheads

4.2.1 A watertight bulkhead is to be fitted at the aft of the hold area. Other watertight bulkheads are to be fitted as necessary to provide transverse strength and watertight subdivision.

SECTION 5 Towing arrangements

5.1 General

5.1.1 All barges and pontoons are to be fitted with adequate arrangements for towing. In general, such arrangements shall consist of not less than two sets of bollards, each of which shall be suitable for accepting a towline with a working load equal to the breaking strength of the towline required by Part 3.

SECTION 6 Equipment

6.1 Manned Barges and pontoons

6.1.1 For manned barges and pontoons the required equipment should be in accordance with Part 3.

6.1.2 Where more than two anchors are required, the spare anchor may be used as a stern anchor.

6.2 Unmanned barges and pontoons

6.2.1 For unmanned barges and pontoons the number of anchors may be reduced to one and the length of the chain cable to 50% of the length required by Part 3.

CHAPTER 4 FLOATING CRANES

SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to vessels intended to have the service notation FLOATING CRANE and are specially designed to operate in a harbour or sheltered water environment where there is no significant movement of the vessel due to wave action and the sea state is not worse than that described for Beaufort No. 2.

1.1.2 Unless otherwise mentioned in this Chapter, the requirements of Part 3 are applicable, taking into account necessary strengthening for supporting the crane during operation and in stowed condition at sea.

1.2 Definitions

1.2.1 For vessels with swim ends, the length L may be measured to the outside surface of the rake plating at the summer load waterline.

1.2.2 Where swim ends are fitted both fore and aft, or where a swim end is arranged aft but no rudder is fitted, then L need not exceed 97% of the extreme length on the summer load waterline.

1.3 Information required

1.3.1 In addition to the information specified in Part 3, the following documents are to be submitted for approval:

a. Supporting structures and strengthening of hull in way of supports.

b. Electrical installations for the crane.

c. Intact and damage stability calculations.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be carried out in accordance with the requirements of Part 3.

SECTION 3 Hull envelope plating

3.1 Bottom shell plating

3.1.1 The minimum thickness of the bottom plating is to be increased by 30% above the minimum thickness required in Part 3.

3.1.2 Where swim ends are fitted the bottom shell plating is to be maintained up to the summer load waterline for the rake plating. Above this point, the thickness may be tapered to that of the side shell requirements from a point not less than 1 m above the load waterline.

3.2 Side shell plating

3.2.1 The minimum thickness of the side shell plating is to be increased by 10% against the minimum thickness required in Part 3.

3.3 Deck plating

3.3.1 The minimum thickness of the deck plating is to be increased by 10% against the minimum thickness required in Part 3.

SECTION 4 Crane system

4.1 General

4.1.1 The forces and loads acting on the crane structure are to be determined in accordance with the operating and environmental conditions for which the crane is to be certified and must be clearly specified together with the speeds of all crane movements, braking times, lifting capacities, ranges, etc.

4.1.2 A recognised national standard will be considered as an alternative basis for approval of cranes provided the Society is satisfied that the criteria are at least equivalent to the design criteria specified in this Section.

4.2 Design loads

4.2.1 The crane structure has to be examined for the operation condition, taking into account the following forces and loads:

a. Dead loads.

b. Lifting loads.

c. Dynamic forces due to hoisting.

d. Slewing forces.

e. Forces due to vessel motions.

f. Wind forces.

g. Loads on access ways and platforms.

4.2.2 The crane structure and any stowed arrangements are to be examine for the stowage condition, taking into account the following forces:

a. Forces due to vessel motions.

b. Wind forces.

4.3 Static loads

4.3.1 The dead load Fd is the self-weight of any component of the lifting appliance which is not included in the lifting load.

4.3.2 The lifting load FL is the maximum static load which the appliance is certified to lift, together with the static weight of any component of the crane structure which is directly connected to, and undergoes the same motion as, the dead load during the lifting operation.

4.4 Dynamic forces due to hoisting

4.4.1 The dynamic forces due to hoisting F_H are those imposed on the structure by shork and accelerating the lifting load F_L from rest to a steady hoisting speed.

4.4.2 The dynamic forces due to hoisting are to be obtained from the following formula:

$$F_H = F_L \cdot C_H, \text{ N}$$

Where:

F_H = lifting load, in N.

C_H = Hoisting factor

= 1 + 0,3 V_H

V_H= Hoisting speed, m/s, but need be taken as not greater than 1.0 m/s.

4.5 Slewing forces

4.5.1 The inertia forces acting on the lifting load and crane structure resulting from slewing the crane are to be considered.

4.5.2 The slewing acceleration is to be supplied by the manufacturer. Where this is not available the acceleration at the jib head of the crane, with the crane jib at maximum radius, is to be taken as 0.6 m/s².

4.6 Forces due to vessel motions

4.6.1 Floating cranes are to be designed to operate safely and efficiently in a harbour or sheltered water environment at an angle of heel of 5° and an angle of trim of 2° occurring simultaneously.

4.6.2 Special consideration will be given where it is intended to operate a floating crane at an angle of heel differing from 5o or an angle of trim differing from 2°.

4.6.3 The forces due to vessel motions are to be determined in accordance with Table 4.6.1.

Table 4.6.1: Forces due to vessel motions

Motion		Component of force, N		
		Normal to deck	Parallel to deck	
			Transverse	Longitudinal
Static	Roll	$w \cdot \cos \varphi$	$w \cdot \sin \varphi$	-
	Pitch	$w \cdot \cos \psi$	-	$w \cdot \sin \psi$
	Combined	$0.91 \cdot w$	$0.40 \cdot w$	$0.10 \cdot w$
Dynamic	Roll	$\pm 0.07 \cdot w \cdot \frac{\varphi}{T_R^2} \cdot y$	$\pm 0.07 \cdot w \cdot \frac{\varphi}{T_R^2} \cdot z_R$	---
	Pitch	$\pm 0.07 \cdot w \cdot \frac{\psi}{T_P^2} \cdot x$	---	$\pm 0.07 \cdot w \cdot \frac{\psi}{T_P^2} \cdot Z_P$
	Heave - Roll	$\pm 0.05 \cdot w \cdot \frac{L}{T_H^2} \cdot \cos\varphi$	$\pm 0.05 \cdot w \cdot \frac{L}{T_H^2} \cdot \sin\varphi$	---
	- Pitch	$\pm 0.05 \cdot w \cdot \frac{L}{T_H^2} \cdot \cos\psi$	---	$\pm 0.05 \cdot w \cdot \frac{L}{T_H^2} \cdot \sin\psi$

w = Weight of crane or its component part, in N.

= Vessels length, as defined in 1.2, in m.

T_R = Roll period, in s.

T_P = Pitch period, in s.

T_H = Heave period, s.

= Longitudinal distance parallel to the deck from centre of pitching motion, taken to be at longitudinal entre of floatation to the centre of gravity of the crane system, in m.

= Transverse distance parallel to deck from centreline of the vessel to the centre of gravity of crane system, m.

z_R = Distance normal to deck from centre of rolling motion, taken to be at the vertical centre of gravity of the vessel to the vertical centre of gravity of the crane system, in m.

z_p = Distance normal to deck from centre of pitching motion to the centre of gravity of the crane system, in m.

ϕ,ψ= in degrees.

4.6.4 The following combination of static and dynamic forces are to be considered:

a. Rolling motion only: static roll + dynamic roll + dynamic heave at roll angle ϕ.

b. Pitching motion only: static pitch + dynamic pitch + dynamic heave at pitch angle ψ.

c. Combined motion: static combined + 0.8·(dynamic roll + dynamic pitch).

In each case the component of force due to wind is to be included where applicable.

4.6.5 In the stowed condition the crane structure and any stowed arrangements are to be designed to withstand forces resulting from the following two design combinations:

a)

1. Acceleration normal to deck of ± 1.0 g.
2. Acceleration parallel to deck in fore and aft direction of ± 0.5 g.
3. Static heel of 30°.
4. Wind of 63 m/s acting in fore and aft direction.

b)

1. Acceleration normal to deck of ± 1.0 g.
2. Acceleration parallel to deck in transverse direction of ± 0.5 g.
3. Static heel of 30°.
4. Wind of 63 m/s acting in a transverse direction.

4.7 Wind forces

4.7.1 The wind pressure acting on the crane structure is given by the formula:

$$p = 0.613 \cdot v^2 \text{ , N/m}^2$$

where:

v= Wind speed, m/s.

The wind speed for the “in service” condition is to be taken as 20 m/s and for the stowed condition as 63 m/s.

4.7.2 Where it is anticipated, that wind speeds in excess of those defined in 4.7.1 may occur, then these higher wind speeds are to be considered.

4.7.3 The wind force acting on the suspended load is to be taken as 300 N per tonne of lifting load, but where a floating crane is to be designed to lift loads of a specific shape and size, the wind force may be calculated for the appropriate dimensions and configuration.

4.7.4 The wind force on the crane structure or individual members of the structure is to be calculated from the following expression:

$$F_w = A \cdot p \cdot C_f \text{, N}$$

where:

A= Solid area projected on to a plane perpendicular to the wind direction, m².

p = Wind pressure (see 4.7.1), in N/m².

C_f= Force coefficient in the direction of wind.

= 1.6 for individual members (rolled sections, rectangles, hollow sections, flat plates).

= 1.1 for machinery houses, etc. (rectangular clad structures on ground or solid base).

4.7.5 For latticed tower structures, the wind force based on the solid area of the windward fare (see 4.7.4) is to be multiplied by the coefficient C_{f1} = 2.6.

4.8 Platform and access-way loading

4.8.1 Platforms and access-ways are to designed to carry a uniformly distributed load over the full platform area of 5000 N/m² and a concentrated load of 3000 N on any individual member.

4.9 Load cases

4.9.1 The crane design is to be considered with respect to loads resulting from the following conditions:

1 Load case 1: crane operating without wind.

2 Load case 2: crane operating with wind.

3 Load case 3: crane in stowed condition.

4.9.2 Load case 1

For the condition of the crane operating without wind the design is to be considered with respect to a combination of static loads (see 4.3) and horizontal forces defined in 4.4, 4.5 and 4.6, as given by the following formula:

$$F1 = 1.05 \cdot (F_D+F_{D1}+F_H+F_{L1} \cdot C_H+F_{S1}), \text{ N}$$

where:

F_D= Dead load, N.

F_{D1} = Horizontal component of dead load due to heel and trim, N.

F_H = Dynamic force due to hoisting (see 4.4.2), N.

F_{L1} = Horizontal component of live load due to heel and trim (see 4.6), N.

C_H = Hoisting factor, as specified in 4.4.2.

F_{S1} = Horizontal load due to slewing acceleration (see 4.4.2), N.

4.9.3 Load case 2

For the condition of the crane operating with wind the design is to be considered with respect to a combination of static loads (see 4.3) and horizontal forces defined in 4.4, 4.5, 4.6 and 4.7, as given by the following formula:

$$F_2 = F_1+F_w, \text{ N}$$

where:

F_1 = Load as defined in 4.9.2.

F_w = Wind force (see 4.7), N.

4.9.4 Load case 3

The crane is to be considered in its stowed condition when subjected to forces resulting from accelerations due to the vessel motions and static inclination together with wind forces appropriate to the stowed condition. The effects of anchorages, locks and lashings, etc. are to be taken into consideration.

CHAPTER 5 FIRE FIGHTING VESSELS

SECTION 1 General

1.1 Application

1.1.1 In addition to the documentation required for the main class, the following plans and particulars are to be submitted:

- A general arrangement plan showing the disposition of all fire-fighting equipment.
- A general arrangement plan showing the disposition of fire divisions and their class.
- Stability calculations.
- Plans showing the layout and capacity of the water spraying system.
- Plans of any other fire-fighting systems provided.
- Construction plan of the fire doors.
- A plan of the seating arrangements for the water monitors.
- Details of major items of fire-fighting equipment.
- Detailed plans of the fire divisions
- Particulars of the means of keeping the ship in position during fire-fighting operations.
- A plan showing the fire pumps, the fire water main, the hydrants, hoses and hose nozzles and the monitors and their delivery capabilities.
- Details of the fireman's outfits provided.
- The Operation Manual

1.2 Testing

1.2.1 After the completion of the installation of the fire-fighting systems and the corresponding equipment, appropriate tests, should be carried out in order to ensure that the vessel is able to operate as intended.

1.2.2 During the testing, the angle of list should be measured when various combinations of water monitors are in operation.

SECTION 2 Basic requirements

2.1 Structural design

2.1.1 The hull structure of the ship should be strengthened so that the vessel to be capable to withstand the forces which are expected to be imposed during the fire-fighting operations by the fire extinguishing systems.

2.1.2 The structural design of the ship should be based on the most adverse operational conditions.

2.1.3 All sea-suctions of the fire pumps should be located as low as practicable.

2.1.4 The compartment in which the driving units of the fire-fighting pumps are located should be considered as “machinery space”.

2.1.5 In ships which are not provided with a water spray system all portlights and windows are to be provided with efficient deadlights or external sheet shutters except in the wheel house.

2.2 Maneuverability

2.2.1 The ship should be provided with the necessary arrangements which will give to the ship adequate maneuverability during fire-fighting operations under the most unfavorable expected conditions.

2.2.2 The most unfavorable maneuverability requirements for calm water operation should not require more than 80% of the available propulsion force in any direction.

2.3 Stability

2.3.1 The effect of the monitors, when they are operating at their maximum output in all possible directions of use, should be taken into account in the stability calculations.

2.3.2 The ship should comply with the corresponding stability and draught requirements imposed by the National Authority.

2.4 Lights

2.4.1 At least two horizontally and vertically adjustable searchlights should be provided for operations in darkness.

2.4.2 The lights should provide a level of illumination of 50 lux within an area of not less than 10 m diameter, at a distance of 250 m, in clear atmospheric conditions.

2.5 Operation Manual

2.5.1 The Operational Manual which should be always kept onboard should include the following information:

a. Detailed description of all fire-fighting and self protection systems and equipment.

b. Detailed and Clear instructions for the operation, maintenance and testing of all fire-fighting and self protection systems and equipment.

c. Instructions for operation of the vessel during fire-fighting, including bunkering operations while the ship is operating on station.

SECTION 3 Fire-extinguishing systems

3.1 Water monitor system

3.1.1 Requirements concerning the minimum number of monitors, their discharge rate, the length and the height of the produced jet above the sea level are given in Table 3.2.1.

3.1.2 The monitors and their seating arrangement are to be of robust construction and of appropriate strength for all modes and conditions of operation.

3.1.3 The horizontal angular movement of the monitors is to be at least ± 90° from the center line of the vessel.

3.1.4 The monitors are to be arranged so that the required length and height of jet can be achieved when all monitors are operating simultaneously along the center line of the vessel. Means should be provided for preventing impact of the jets on the ship's structure.

3.1.5 Two of the monitors should be provided with jet dispersion arrangements.

3.1.6 All monitors should be remotely controllable from a protected position providing a good view of the monitors and the operating area.

3.2 Pumps and piping systems

3.2.1 The applicable requirements for pumping and piping systems covered by the main class are to be complied with.

3.2.2 The required number of pumps and the minimum total pump capacities are specified in Table 3.2.1.

3.2.3 The pumps and their piping system which are intended for fire-fighting and self-protection are not to be available for other services and they should be provided with independent sea inlets.

3.2.4 Where the pumps are used for self-protection, the piping is to be independent of that supplying the monitors.

3.2.5 Sea-valves with nominal diameter greater than 450 mm are to be power actuated and manually operable as well.

3.2.6 Arrangements should be provided for the prevention of starting of the fire-fighting pumps when the water inlet valves are closed.

3.2.7 The design maximum water velocity in the suction lines should normally not exceed 2 m/s.

3.2.8 Piping from seawater inlets to water monitors should be protected against corrosion internally. External protection is required for all piping exposed to the weather.

Table 3.2.1: Fire-extinguishing equipment

Category	I	II		III
Monitors				
Number (min.)	2	3	4	4
Minimum discharge rate per monitor (m^3/h)	1200	2400	1800	2400
Length of jet (1) (m)	120	150		150
Height of jet (2) (m)	50	80		90
Minimum fuel oil capacity (h)	24	96		96
Pumps and Piping Systems				
Minimum total pump capacity (m^3/h)	2400	7200		9600
Number of pumps	1-2	2-4		2-4
Number of hose connections each side of ship	4	8		8
Fireman's Outfits				
Number of fireman's outfits	4	8		8

NOTES:
1. Length is considered to be the horizontal distance from the mean impact area to the nearest point of the vessel.
2. Height is considered to be the vertical distance from the sea level to the mean impact area measured at a horizontal distance at least 70 m from nearest point of the vessel.

3.3 Hose connections and hose stations

3.3.1 The required number of hose connections for each ship category is given in Table 3.2.1.

3.3.2 Hose stations should be provided for at least half the number of the hose connections. Each hose station should be provided with 2 x 15 m hose and a nozzle capable of producing a jet or a spray and simultaneously a jet and a spray.

3.4 Fireman's Outfits

3.4.1 The required number of fireman's outfits is given in Table 3.2.1 for each ship category.

3.4.2 A fireman's outfit shall consist of:

a. Protective clothing of material to protect the skin from heat radiating from the fire and from burns and scalding by steam. The outer surface is to be water-resistant.

b. Boots and gloves of rubber or other electrically non-conducting material.

c. A rigid helmet providing effective protection against impact.

d. An electric safety lamp (hand lantern) of an approved type with a minimum operating period of 3 hours.

e. An axe with an insulated handle.

f. A self-contained breathing apparatus which is to be capable of functioning for a period of at least 30 minutes and having a capacity of at least 1200 litters of free air. Spare, fully charged air bottles are to be provided at the rate of at least one set per required apparatus.

For each breathing apparatus a fireproof life-line of sufficient length and strength is to be provided capable of being attached by means of a snaphook to the harness of the apparatus or to a separate belt in order to prevent the breathing apparatus becoming detached when the life-line is operated.

3.4.3 The fireman's outfits should be placed in a separate fire station the entrance of which should be clearly marked.

3.4.4 A suitable air compressor for recharging the bottles of the breathing apparatus of the fireman's outfit should be provided. The capacity of the compressor should be at least 70 lt./min.

SECTION 4 Self-protection

4.1 General

4.1.1 Vessels which have been assigned the special notation "SP" should be protected by a permanent water spraying system in accordance with the requirements of this section.

4.2 Fixed water-spraying system

4.2.1 The system should be designed so that to protect all outside vertical parts of hull, superstructures and deckhouses including foundations for water monitors and other equipment.

4.2.2 Pipelines and nozzles should be protected against damage during the fire-fighting operations.

4.2.3 The capacity of the water spraying system should not be less than 10 $lt/(min{\cdot}m^2)$ for all areas under protection. In case of protected areas which are internally insulated to a A-60 standard the required capacity should not be less than 5 $lt/(min{\cdot}m^2)$.

4.2.4 The system should be divided into sections in order to be possible to stop the operation of the system in areas which are not exposed to heat.

4.2.5 The pumps of the fire-fighting system may also be used to the spraying system provided that their capacity is properly increased by the capacity required by the latter. In this case a shut-off valve should be fitted in a proper position between the main piping of the two systems.

4.2.6 Sufficient freeing ports and deck scuppers should be provided so that to ensure efficient drainage of accumulated water under all conditions and modes of operation.

CHAPTER 6 OIL RECOVERY VESSELS

SECTION 1 General

1.1 Classification

1.1.1 The requirements in this Section apply to vessels intended for occasionally handling, storage and transportation of oil with flash point below 60°C, recovered from a spill of oil, in emergency situations.

1.1.2 Vessels built and equipped in compliance with the following requirements may be given the class notation OIL RECOVERY SHIP.

1.1.3 In case of ships engaged in oil recovery operations and which either:

a. operate in certain, strictly defined sea areas, or,
b. are of novel design, or,
c. are of limited operational capabilities,

Special consideration may be given and a corresponding class notation to be assigned.

1.2 Scope

1.2.1 The following matters are covered by the classification:

a. safety against fire and explosion during handling, storage and transportation of oil recovered from a spill on sea,
b. supporting structures for equipment applied during oil recovery operations,
c. stability and floatability,
d. available power for supply to equipment used during oil recovery operations.

1.3 Assumption

1.3.1 The classification of the vessel is based on the assumption that the operation of the vessel during oil recovery operation will be in accordance with the approved operation manual, see 5.1.

1.4 Documentation

1.4.1 General arrangement plan(s) showing the following particulars is to be submitted for approval:

a. gas-dangerous zones and spaces
b. location of equipment for reception and handling of oil such as pumps, skimmer, winches, etc.
c. tanks intended for storage of recovered oil with accesses
d. oil tank venting arrangement
e. doors, hatches, ventilation openings and any other openings to gas-dangerous spaces and adjacent safe spaces
f. ventilation arrangement for gas-dangerous spaces and adjacent safe spaces
g. exhaust outlets from machinery
h. fire extinguishing equipment and structural fire protection, see however 1.4.3.
i. electrical equipment in gas-dangerous areas with specification of explosion protected equipment, together with certificates.

1.4.2 The following plans and particulars are to be submitted for approval:

a. diagrammatic plan of piping system for handling of oil

b. plan showing supporting structures and fastening arrangements for equipment applied during oil recovery operations. Reaction forces to be stated.

c. diagrammatic plan of power supply system for equipment used during oil recovery operations

d. single line diagram for intrinsically safe circuits

e. electric power balance for oil recovery operations, if applicable

f. specification of gas-measuring instrument

j. stability and floatability calculation of the vessel in the operating mode, however, see 1.4.3.

g. operation manual.

1.4.3 In the case that fire extinguishing equipment and structural fire protection and/or stability and floatability have been approved by a National administration applying requirements which may be considered equivalent to those of the class, such approval, satisfactorily documented, may be accepted as evidence of compliance with the class requirements.

1.5 Testing

1.5.1 Upon completion, the procedure for transfer to oil recovery operation of the vessel is to be demonstrated and such operation is to be simulated to verify that the vessel will be able to operate as intended.

SECTION 2 Basic requirements

2.1 General

2.1.1 The vessel is to be provided with:

a. a suitable working deck for use in oil recovery operation,

b. storage tanks for recovered oil,

c. pumping and piping arrangement for transfer and discharge of recovered oil.

2.1.2 The vessel is to have adequate stability and floatability in all relevant operational conditions. The stability and floatability properties will be considered in each particular case.

2.1.3 The visibility from the maneuvering station is to be such that the Master can easily monitor oil recovery operations both on deck and in the water.

2.1.4 The oil tanks and the deck area, from where the operation is performed, are to be as far away from the accommodation as possible.

2.1.5 Exhaust outlets from machinery are to be located as high as practicable above the deck and are to be fitted with spark arresters.

2.2 Fire protection and extinction

2.2.1 Exterior boundaries of superstructures and deckhouses enclosing accommodation and including any over hanging decks which support accommodation, are to be insulated to “A-60” standard for the whole of the portions which face the gas dangerous zones and for 3 m aft or forward of these, whichever is relevant. Alternatively a permanently installed water-spraying system in compliance with 2.2.3 may be accepted. Aluminium bulkheads will not be accepted in these boundaries.

2.2.2 Portholes or windows in the area specified in 2.2.1 are to be fitted with permanently installed inside deadlights of steel having a thickness equal to the steel in the bulkhead.

2.2.3 If impractical to fit deadlights, navigating bridge windows and other windows in the area specified in 2.2.1 are to be protected by a sprinkler system having a capacity of at least 10 litres/min/m². The system is to be fully activated by opening of one valve on the bridge.

2.2.4 For protection of the working deck area two dry powder fire extinguishers, each with a capacity of at least 50 kg, are to be provided. In addition, a foam applicator is to be provided. The quantity of foam concentrate is to be at least 0,4 litres/m² working deck area, minimum 200 litres. The foam expansion ratio is generally not to exceed 12 to 1. The fire extinguishers are to be placed near the deck area where the equipment for handling of recovered oil is located, and are to be fitted with hoses of adequate length.

2.3 Tank arrangement

2.3.1 Tanks within the accommodation and/or engine room area of the vessel are in general not to be used for storage of recovered oil.

2.3.2 Tanks intended for storage of recovered oil are normally to be separated from the engine room and accommodation by means of cofferdams, tanks for other purposes (fuel oil, ballast etc.) or dry compartments other than accommodation. For easy access to all parts, the cofferdams are to have a minimum width of 600 mm.

2.3.3 Where cofferdams are impractical to arrange, tanks adjacent to the engine room may be accepted for storage of recovered oil provided that tank bulkhead is:

a. accessible for inspection
b. carried continuously through abutting plate panels, except that full penetration welding may be used at the top of the tank
c. pressure tested at every periodical survey.

2.3.4 Upon special consideration double bottom tanks in the engine room area may be used for storage of recovered oil. The arrangement of pipes and openings between tanks is to be such that static pressure on the double bottom tank top is prevented. Level alarms are to be fitted.

2.3.5 A tank arrangement requiring removable manhole covers is to be avoided. Open manholes between a maximum of 3 tanks may be accepted, provided the manhole covers are removable from ballast or fresh water tanks.

2.3.6 All openings to the tanks (sounding pipes, hatches for placing of portable pumps and hoses) for recovered oil are to be located on open deck.

2.3.7 Tanks for recovered oil are to have suitable access from open deck for cleaning and gas-freeing. Long tanks are to have access in both ends.

2.3.8 Tanks exceeding a breadth of 0.56 B or a length of 0.1 L or 12 m whichever is the greater are normally to be provided with wash bulkheads or similar arrangement to reduce liquid sloshing in partially filled tanks.

2.3.9 The height of tanks for recovered oil is not to be less than 1.5 m. Internal obstructions in tanks for recovered oil are to be provided with adequate openings to allow a full flow of oil. The area of one single opening is for that purpose not to be less than twice the sectional area of the discharge pipe. The openings are to be arranged that the tanks can be effectively drained.

2.3.10 Any coating in tanks for recovered oil is to be of an oil and dispersion resistant type.

2.4 Support of heavy components

2.4.1 The strength of the supporting structures for equipment applied during oil recovery operations can be based on the assumption that the oil recovery operations will take place in moderate sea conditions.

2.4.2 For cranes intended for use during oil recovery operations, dynamic loads due to the vessel's motions are to be taken into account. In general the cranes and their supporting structures are to have scantlings based on at least twice the working load of the crane.

SECTION 3 Gas-dangerous and Safe Areas

3.1 Definitions

3.1.1 The following spaces are to be considered as gas dangerous spaces during oil recovery operations:

a. tanks for storage of recovered oil,

b. enclosed or semi-enclosed spaces in which pipe flanges, valves, hoses, pumps and/or other equipment for handling of recovered oil are located.

3.1.2 The following spaces are to be considered as gas dangerous if the requirements to ventilation given in 4.2.4 are not complied with:

a. cofferdams and spaces adjacent to tanks intended for storage of recovered oil,

b. enclosed or semi-enclosed spaces having access or opening into other gas-dangerous areas,

c. any enclosed space outside the recovered oil tank area through which piping which may contain recovered oil passes or terminates.

3.1.3 Gas-dangerous zones are:

zones on the open deck or semi-enclosed spaces on the deck within a distance of 3 m from oil skimmer equipment, hoses and valves used for recovered oil handling, openings and air pipes from tanks for recovered oil and openings and ventilation outlets from gas-dangerous spaces.

The open over tanks intended for storage of recovered oil and 3 m forward and aft of this area on the open deck up to height of 2.4 m above the deck.

3.1.4 Safe areas are areas which are not defined as gas-dangerous in the above.

3.2 Access and other openings

3.2.1 There are normally not to be access doors or other openings between a safe room and gas-dangerous area. Access doors may, however, be accepted between such spaces on the following conditions:

a. the safe room is to have ventilation overpressure in relation to the gas-dangerous area

b. the doors are normally to be self-closing and arranged to swing into the safer space so that they are kept closed by the overpressure

c. signboards are to be fitted warning that the doors are to be kept closed during oil recovery operations.

SECTION 4 Arrangement and equipment

4.1 General

4.1.1 The vessel is to be arranged and equipped so as to minimize the time needed to make it operational. This implies that systems and equipment for handling of recovered oil as far as practicable are to be permanently installed.

4.1.2 Systems and arrangements are to be such that procedures for and practical execution of filling, venting, discharge, sounding, etc. will be simple to perform.

4.1.3 All electrical and mechanical equipment for use in gas-dangerous areas during oil recovery operations is to be certified for operation in gas contaminated atmosphere.

4.2 Ventilation system

4.2.1 There are to be independent ventilation for gas-dangerous and safe spaces.

4.2.2 Safe spaces adjacent to gas-dangerous areas are normally to have mechanical ventilation with overpressure relative to gas-dangerous areas. The inlet air is to be taken from a safe area on open deck located as far as practicable from possible gas sources. Also the outlet air is normally to be led to a safe area on open deck. Location of the outlet in an open deck gas-dangerous zone may, however, be considered, depending upon the arrangement in each case.

4.2.3 Gas-dangerous spaces are normally to have mechanical ventilation of extraction type, giving at least 8 changes of air per hour. The inlet air is to be taken from a safe area on open deck.

4.2.4 Spaces which normally would be regarded as gas-dangerous spaces according to 3.1.2 above may be accepted as safe on the condition that the following special requirements to ventilation in addition to those given in 4.2.2 above are complied with:

a. the ventilation capacity is to be at least 20 changes of air per hour

b. the arrangement of ventilation inlet and outlet openings in the room is to be such that the entire rooms is efficiently ventilated, taking special consideration to locations where gas may be released or accumulated.

4.3 Tank venting system

4.3.1 Ventilation outlets from the tanks are to be led to open deck.

The outlets are to have a minimum height of 2.4 m above deck and be located at a minimum horizontal distance of 5 m away from openings to accommodation and other gas-safe spaces, ventilation intakes for accommodation and engine room and non-certified safe electrical equipment.

4.3.2 Portable ventilation outlet pipes intended for use during oil spill recovery operations only, may be accepted.

4.3.3 The venting arrangement is in general to comply with the requirements given for the main class.

4.4 Arrangement of piping systems

4.4.1 The system for pumping and transfer of recovered oil is to be located outside engine room and accommodation.

4.4.2 The transfer system is to be arranged such that simultaneous filling and discharge will be possible.

4.4.3 For coupling of portable skimming equipment one or maximum two filling connections with branch pipes to all tanks for recovered oil are to be arranged on deck.

4.4.4 The filling line is to be provided with means for injection of emulsion-breaking chemicals. The arrangement is to be so as to facilitate efficient mixing with recovered oil, e.g. by injection to the suction side of a pump. For tanks provided with heating coils the requirements may be dispensed with.

4.4.5 Where permanently installed oil recovery piping is incompatible with the normal cargo system, suitable blanking arrangements are to be provided.

4.4.6 Parts of existing piping and pumping systems may be used if found to satisfy the general safety principles. Such arrangements will be evaluated in each case.

4.4.7 The internal diameter of sounding pipes from tanks for recovered oil is to be less than 50 mm. The sounding pipes are to be located on open deck.

4.4.8 For all piping connections other than mentioned above, blanking-off before oil is loaded into the tanks is to be possible. The blanking device is to be fitted to the nearest detachable pipe connection at the tank.

4.5 Power supply and electrical equipment

4.5.1 The following equipment will be accepted in gas-dangerous areas:

a. flameproof, pressurized, increased safety or intrinsically safe equipment

b. cables complying with the requirements of Part 6, Chapter 6, SECTION 1, 1.1.

4.5.2 Means for disconnection of electrical supply to non-certified electrical equipment in gas-dangerous spaces is to be arranged. Signboards are to be fitted at the respective switches. Electrical cables led through these spaces and electrical equipment in the machinery spaces are exempted.

4.5.3 Non-certified safe electrical equipment located in gas-dangerous zones on open deck are to be disconnected during oil recovery operation.

4.5.4 The arrangement of power supply to non- permanent oil skimming and pumping equipment is as far as practicable to be permanently installed. For circuits with higher rating, the outlet is to be arranged from a connection box, provided with a door which is interlocked with a switch. The supply from the main switchboard to the connection box or socket-outlet is to be permanently installed, and provided with separate switchgear with short-circuit and overcurrent protection in each insulated phase.

4.5.5 Non-permanent oil skimming and pumping equipment and independent power-packages are to be certified as safe for operation in gas-contaminated atmosphere.

4.5.6 The socket-outlet and connection boxes mentioned in 4.5.4 are to be located at easily accessible places and in such a way that flexible cables are not carried through doors or accommodation spaces.

4.6 Miscellaneous requirements

4.6.1 A portable hydrocarbon gas-measuring instrument of approved type is to be provided on board.

4.6.2 The deck area where handling of hoses and equipment for recovered oil takes place is to be provided with adequate lighting.

4.6.3 A low sea suctions is to be arranged for cooling water pumps for machinery.

4.6.4 Exhaust pipes or any other pipes with surface temperature exceeding 220°C are not to pass through gas-dangerous spaces.

4.6.5 Signboards are to be fixed by screws, rivets or equal.

SECTION 5 Operational Instructions

5.1 General

5.1.1 The vessel is to have an approved operation manual onboard. The manual is to give information regarding the safe use of the vessel during oil recovery operations and is to have references to enclosed drawings.

5.1.2 The operation manual is in general to give information regarding the following:

a. Arrangement and equipment

1. tank arrangement
2. transfer system
3. gas measuring instrument
4. various equipment

b. Mobilization

1. checking of all equipment taken onboard to ascertain that it is certified for use in gas-contaminated atmospheres
2. mounting and fastening of non-permanent equipment
3. blanking-off of pipes
4. assembling of air pipes
5. disconnection of electrical power supply
6. closing of openings between safe and gas-dangerous areas
7. start of additional ventilation equipment
8. change-over to low suction for cooling water pumps
9. fitting of signboards regarding the use of open flame, non-certified electrical equipment etc.

c. Operation

1. guidelines regarding safe distance from an oil spill source. If gases are traced on open deck, the vessel is to be withdrawn immediately.
2. gas measurements during operation (on open deck and in spaces where gas might accumulate)
3. actions to be taken if gases are traced in enclosed spaces (cleaning, ventilation, emptying of adjacent tanks, etc.)
4. precautions against overfilling of tanks
5. discharging

d. Cleaning and gas-freeing of tanks and pipes

e. Stability in all relevant operational conditions

Rules and Regulations

for the

Classification and Construction of

SMALL CRAFTS

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PHOENIX REGISTER OF SHIPPING

Part 1 – Classification

Part 2 - Materials

Part 3 - Hull Construction and Equipment

Part 4 - Specialized Vessels

Part 5 - Machinery

Part 6 - Electrical Installations

Part 7 - Fire Protection, Detection and Extinction

Part 8 – Control Engineering Systems

PHOENIX REGISTER OF SHIPPING

Part 5 - Machinery

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CHAPTER 1 GENERAL REQUIREMENTS

SECTION 1 General

1.1 Application

1.1.1 The requirements of Part 5, Chapter 1, Chapter 2, Chapter 3 and Chapter 4 are applicable to main propulsion and essential auxiliary machinery where the total input power to each propeller shaft is not greater than 500 kW (680 shp). Craft fitted with oil engines where the total input power to each propeller shaft exceeds 500 kW (680 shp) are to comply with the relevant requirements of the "*Rules and Regulations for the Classification and Construction of Steel Ships".*

1.1.2 The requirements of this Part are not applicable to petrol engines. Such engines, normally, are not acceptable. Where their installation is proposed, special consideration is required.

1.2 Classification survey

1.2.1 Workmanship and materials should be examined by the Surveyors from the beginning of work until the final test of the machinery under full load. After this, the Surveyors will submit a report and if this is found to be satisfactory by the Society a certificate will be granted, and an appropriate notation will be assigned in accordance with Part 1.

1.3 System of inspection of mass produced machinery items

1.3.1 The Society will be prepared to adopt a survey procedure of mass produced machinery items based on quality assurance concepts utilizing regular and systematic audits of the approved manufacturing and quality control processes and procedures as an alternative to the direct survey of individual items.

1.3.2 In order to obtain approval, the requirements of SECTION 7 are to be complied with.

1.4 Deviation from the Rules

1.4.1 Requests for departure from the requirements of the Rules, due to special circumstances, will be subject to special consideration.

SECTION 2 Documents for approval

2.1 Plans

2.1.1 Plans in triplicate, of all machinery items, as detailed in the Chapters giving the requirements for individual systems, are to be submitted for consideration, before the commencement of the work. The particulars of the machinery, including power ratings and design calculations, where applicable, necessary to verify the design, are also to be submitted. Any subsequent modifications or alterations to initial design, materials or manufacturing procedure are to be re-submitted for consideration. A plan showing the arrangement of the machinery is also to be submitted.

2.2 Materials

2.2.1 The requirements for the materials used in the construction of all machinery items are those described in Part 2 of the present Rules. Materials for which provision is not made therein may be accepted, provided that they comply with an approved specification and such tests as may be considered necessary.

SECTION 3 Operating conditions

3.1 Ambient reference conditions

3.1.1 For the purpose of determining the power of main and auxiliary reciprocating internal combustion engines, the following ambient reference conditions apply:

a) Total barometric pressure 1000 mbar
b) Air temperature +45°C
c) Relative humidity 60%
d) Sea water temperature 32°C
(charge air coolant-inlet)

NOTE: The engine manufacturer shall not be expected to provide simulated ambient reference conditions at a test bed.

3.1.2 The ambient conditions specified in Table 3.1.1 are to be applied to the layout, selection and arrangement of all shipboard machinery, equipment and appliances as to ensure proper operation.

Table 3.1.1: Temperatures

a) Air

Installations, components	Location, arrangement	Temperature range (^{o}C)
Machinery and electrical installations [1]	*In enclosed spaces*	*0 to +45* [2]
	On machinery components, boilers. In spaces subject to higher and lower temperature	According to specific local conditions
	On the open deck	-25 to +45 [2]

b) Water

Coolant	Temperature (^{o}C)
Seawater	+32
Charge air coolant inlet to charge air cooler	+32

NOTES:
1. Electronic appliances are to be suitable for proper operation even with an air temperature of +55 ^{o}C
2. The Society may approve other temperatures in the case of ships not intended for unrestricted service.

3.2 Inclinations

3.2.1 The inclinations specified in Table 3.3.1 are to be applied to the layout, selection and arrangement of all shipboard machinery, equipment and appliances to ensure proper operation.

3.2.2 Any proposal to deviate from the angles given in Table 3.3.1 will be specially considered taking into account the type, size and service conditions of the ship.

3.3 Vibrations

3.3.1 Machinery, equipment and hull structures are normally subjected to vibration stresses. Design, construction and installation must in every case take account of these stresses.

Table 3.3.1: Inclinations

Installations, components	Angle of inclination(°) [2]			
	Athwartships		Fore-and-aft	
	static	dynamic	static	dynamic
Main and auxiliary machinery	15	22,5	5	7,5
Safety equipment, e.g. emergency power installations, emergency fire pumps and their devices Switch gear, electrical and electronic appliances [1] and remote control systems	22,5[3]	22,5[3]	10	10

NOTES:

1. Up to an angle of inclination of 45° no undesired switching or operational changes may occur.
2. Athwartships and fore-and-aft inclinations may occur simultaneously.
3. In ships for the carriage of liquefied gases and of chemicals the emergency power supply must also remain operable with the ship flooded to a final athwartships inclination up to a maximum of 30°.

3.4 Definitions

3.4.1 Units and formulae included in the Rules are shown in SI units.

3.4.2 Where the metric version of shaft power, i.e. (shp), appears in the Rules, 1 shp is equivalent to 75 kgf m/s or 0,735 kW.

3.4.3 Pressure gauges may be calibrated in bar, where:

$$\mathbf{1\ bar = 0{,}1\ N/mm^2 = 1{,}02\ kgf/cm^2}$$

3.5 Fuels

3.5.1 The flash point (closed cup test) of fuel oil for use is, in general, to be not less than 60°C.

3.5.2 Fuels with flash points lower than 60°C require special consideration.

3.6 Power ratings

3.6.1 In the Chapters where the dimensions of any particular component are determined from shaft power, P, in kW, and revolutions per minute, n, the values to be used are to be derived from the following:

a. for main propelling machinery, the maximum shaft power and corresponding revolutions per minute giving the maximum torque for which the machinery is to be classed,

b. for auxiliary machinery, the maximum continuous shaft power and corresponding revolutions per minute which will be used in service.

3.7 Availability of machinery

3.7.1 The ships' machinery is to be so arranged that it can be brought into operation from the "dead ship" condition using only the facilities available on board. "Dead ship" condition is understood to mean that the entire machinery installation, including the power supply, is out of operation and that auxiliary services such as compressed air, starting current from batteries, etc., for bringing the main propulsion into operation and for the restoration of the main power supply are not available. In order to restore operation from the "dead ship" condition, an emergency generator may be used provided that it is ensured that the emergency power supply from it is available at all times. It is assumed that means are available to start the emergency generator at all times.

SECTION 4 Machinery space arrangements

4.1 Accessibility

4.1.1 Equipment are to be so arranged in the engine space that all the erection holes and inspection parts provided by the engine manufacturer for inspections and repairs are accessible.

4.2 Machinery fastenings

4.2.1 All fastenings are to be of robust construction. The machinery is to be securely fixed to the ship's structure to the Surveyor's satisfaction.

4.3 Flexible mountings

4.3.1 The Shipbuilder is to ensure that the vibration levels of flexible pipe connections, shaft couplings and mounts remain always within the limits specified by the component manufacturer. The vibration levels are to be checked in the following conditions:

a. Condition of maximum dynamic inclinations to be expected during service.
b. Start-stop operation.
c. Operation on the natural frequencies of the system.

Due account is to be taken of any creep that may be inherent in the mount.

4.3.2 Anti-collision chocks are to be used to ensure that manufacturers limits are not exceeded. Suitable means are to be provided to accommodate the propeller thrust.

4.4 Ventilation

4.4.1 In spaces where the presence of flammable or toxic gases or vapors is probable adequate ventilation is required.

4.5 Fire protection

4.5.1 All surfaces of machinery where the surface temperature may exceed 220°C and where impingement of flammable liquids may occur are to be properly shielded and insulated.

SECTION 5 Astern power for main propulsion

5.1 General requirements

5.1.1 In order to maintain sufficient maneuverability of a ship in all normal circumstances, the main propulsion machinery is to be capable of running astern.

5.1.2 The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the ahead revolutions for a period of at least 30 minutes. The output astern which may be developed in transient conditions is to be such as to enable the braking of the ship within reasonable time.

5.1.3 For the main propulsion systems with reversing gears, controllable pitch propellers or electric propeller drive, running astern should not lead to the overload of propulsion machinery.

5.1.4 The ahead revolutions as mentioned above are understood as those corresponding to the maximum continuous ahead power for which the vessel is classed. The reversing characteristics of the propulsion plant are to be demonstrated and recorded during trials.

SECTION 6 Trials

6.1 Tests

6.1.1 All tests of particular components and trials of machinery are to be carried out to the satisfaction of the Surveyors, according to the Chapters giving the individual requirements for each part.

6.2 Sea trials

6.2.1 For the sake of reliability, due attention is required to the duration of all sea trials. Sea trials for all types of installation are to be carried out under normal maneuvering conditions, to verify the machinery under power. During the trials and within the operating speed range any generated vibration is not to exceed the manufacturers values.

6.2.2 Diesel engines for main propulsion are to undergo trials as specified in Part 5, Chapter 2, SECTION 4. In case of controllable pitch propellers, the free route astern trial is to be carried out with the propeller blades set in the full pitch astern position. Where emergency manual pitch setting facilities are provided, their operation is to be demonstrated to the satisfaction of the Surveyors.

6.2.3 Before the full power sea trials, in geared installations, the gear teeth are to be suitably coated to demonstrate the contact markings, and on conclusion of the sea trials all gears are to be opened up in order to permit the Surveyors to make an inspection of the teeth. The marking is to indicate freedom from hard bearing, particularly at the ends of the teeth, including both ends of each helix where applicable.

6.2.4 The stopping time, ship headings and distances recorded on trials, together with the results of trials to determine the ability of ships having multiple propellers to navigate and manoeuvre with one or more propellers inoperative, are to be available on board for the use of the master or designated personnel.

SECTION 7 Quality assurance scheme for machinery

7.1 General

7.1.1 The proposed certification scheme is applicable to mass produced items manufactured under controlled conditions and will be restricted to works where the use of quality control procedures is well established. The Society will have to be satisfied that the practices employed will ensure that the quality level of the finished products is equivalent to the standards which would be required from the use of traditional survey methods.

7.1.2 An extensive survey is to be made by the Surveyors of the actual operation of the quality control program including workmanship. The Committee is to consider proposed alternative designs for compliance with the Society's Rules, or other relevant requirements.

7.1.3 The procedures and practices of manufacturers which have been granted approval will be kept under review.

7.1.4 Approval by another organization will normally not be accepted as sufficient evidence that a manufacture's arrangements comply with the Society's requirements.

7.2 Quality systems requirements

7.2.1 A quality system in accordance with requirements of the ISO 9001 Standard may be considered as meeting the requirements of the Society. Other quality systems will be subject to special consideration.

CHAPTER 2 PISTON ENGINES

SECTION 1 General

1.1 Application

1.1.1 The Rules of this Chapter apply to mass-produced internal combustion engines used as main propulsion units or auxiliary units. For the purpose of these Rules, internal combustion engines are diesel engines.

1.1.2 In case of non mass-produced engines, special consideration is required, after taking into account the relevant applicable requirements of Part 5, Chapter 2 of the "Rules and Regulations for the Classification and Construction of Steel Ships".

1.2 Definition of diesel engine type

1.2.1 Engines are of the same type if they don't vary in any detail included in the definition 1.2.2. When two engines are to be considered of the same type it is assumed that they do not substantially differ in design and their design details, crankshaft, etc., and the materials used meet Rule requirements and are approved by the Society.

1.2.2 The type of internal combustion engine expressed by the Engine Builder's designation is defined by:

a. the bore,
b. the stroke,
c. the method of injection (direct or indirect injection),
d. the kind of fuel (liquid, dual-fuel, gaseous),
e. the working cycle (4-stroke, 2-stroke)
f. the gas exchange (naturally aspirated or supercharged)
g. the maximum continuous power per cylinder at maximum continuous speed and /or maximum continuous brake mean effective pressure, [1]
h. the method of pressure charging (pulsating system, constant pressure system),
i. the charging cooling system (with or without intercooler, number of stages),
j. cylinder arrangement (in-line, vee). [2]

NOTES:

1 After a large number of engines has been proved successfully by service experience, an increase in power up to maximum 10% may be permitted, without any further type test, provided approval for such power is given.
2 One type test suffices for the whole range of engines having different numbers of cylinders.

1.3 Documents for the approval of diesel engines

For each type of engine to be approved the document listed in the following

Table 1.3.1 and as far as applicable to the type of engine are to be submitted to the Society for approval (A) or for information (R) by each engine manufacturer (see

1.3.1 Table 1.3.1, 4). After the approval of an engine type has been given by the Society for the first time, only those documents as listed in the table which have undergone substantive changes will have to be submitted again for consideration by the Society. In cases where 2 indications (R/A) are given, the first refers to cast design and the second to welded design. The assignment of the letter R does not preclude possible comments by the Society.

Table 1.3.1: Information for diesel engines.

No.	A/R	Item
1	R	Engine particulars as per attached sheet
2	R	Engine transverse cross-section
3	R	Engine longitudinal section
4	R/A	Bedplate or crankcase, cast or welded with welding details and instructions
5	A	Thrust bearing assembly [3]
6	R/A	Thrust bearing bedplate, cast or welded with welding details and instructions [1]
7	R/A	Frame/column, cast or welded details and instructions
8	R	Tie rod
9	R	Cylinder cover, assembly
10	R	Cylinder jacket or engine block [1 2]
11	R	Cylinder liner [2]
12	A	Crankshaft, details, each cylinder No.
13	A	Crankshaft, assembly, each cylinder No.
14	A	Thrust shaft or intermediate shaft (if integral with engine)
15	A	Coupling bolts
16	A	Counterweights (if not integral with crankshaft)
17	R	Connecting rod
18	R	Connecting rod, assembly [2]
19	R	Crosshead, assembly [2]
20	R	Piston rod, assembly [2]
21	R	Piston, assembly
22	R	Cramshaft drive, assembly
23	A	Material specifications of main parts with information on non-destructive material tests and pressure tests
24	A	Arrangement of foundation bolts (for main engines only)

25	A	Schematic layout or other equivalent documents of starting air system on the engine
26	A	Schematic layout or other equivalent documents of fuel oil system on the engine [6]
27	A	Schematic layout or other equivalent documents of lubricating oil system on the engine [6]
28	A	Schematic layout or other equivalent documents of cooling water system on the engine [6]
29	A	Schematic diagram of engine control and safety system on the engine[6]
30	R	Shielding and insulation of exhaust pipes, assembly
31	A	Shielding of high pressure fuel pipes, assembly [4]
32	A	Arrangement of crankcase explosion relief valve [5]
33	R	Operation and service manuals

FOOTNOTES:

1. only for one cylinder
2. only necessary if sufficient details are not shown on the transverse cross section and longitudinal section
3. if integral with engine and not integrated in the bedplate
4. for attended engine room: only engines with a bore of 250 mm and above for unattended engine room: all engines
5. only for engines with a bore exceeding 200 mm
6. and the entire system, if this is part of the goods to be supplied by the engine manufacturer

NOTES:

1. The approval of exhaust gas turbochargers, charge air coolers, etc., is to be obtained by the respective manufacturer.
2. Where considered necessary, the Society may request further documents to be submitted.
3. The number of copies to be submitted is three.
4. A License is to submit , for each engine type manufactured, a list of all documents required by the Society with the relevant drawing numbers and revision status from both Licenser and Licensee. Where the Licensee proposes design modifications to components, the associated documents are to be submitted by the Licensee for approval or for information. In case of significant modifications a statement is to be made confirming the Licenser's acceptance of the changes. In all cases a complete set of documents will be required by the surveyor(s) attending the Licensee's work.

SECTION 2 Rated Power

2.1 General

2.1.1 Diesel engines are to be capable to deliver their rated power when running at rated speed as a continuous net brake power. Diesel engines are to be capable of continuous operation within power range A in Figure 2.1.1 and of short-period operation in power range B. The extent of the power ranges are to be stated by the engine manufacturer.

2.1.2 For the purposes of this Chapter, continuous power means the net brake power which an engine is capable of delivering continuously, provided that the maintenance prescribed by the engine manufacturer is carried out, between the maintenance intervals stated by the engine manufacturer.

2.1.3 To verify that an engine is rated at its continuous power, it is to be demonstrated that the engine can run at an overload power corresponding to 110% of its rated power at corresponding speed for an uninterrupted period of 1 hour. Deviations from the overload power value require the agreement of the Society.

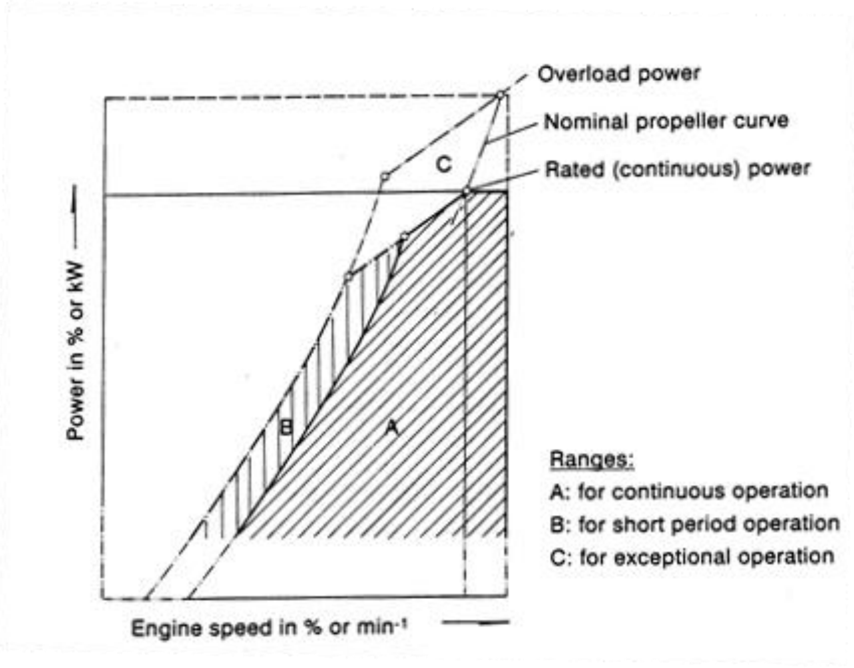
2.1.4 After running on the test bed, the fuel delivery system of main engines is normally to be so adjusted that overload power cannot be given in service.

2.1.5 Subject to the prescribed conditions, diesel engines driving electric generators must be capable of overload operation even after installation on board.

2.1.6 Subject to the approval of the Society, diesel engines for special vessels and special applications may be designed for a continuous power (fuel stop power) which cannot be exceeded.

2.1.7 For main engines, a power diagram (Figure 2.1.1) is to be prepared showing the power ranges within which the engine is able to operate continuously and for short periods under service conditions.

Figure 2.1.1: Example of a power diagram.



SECTION 3 Piping

3.1 Lubricating oil filters

3.1.1 Suitable lubricating oil filters should be used in lubricating oil lines located in the main oil flow on the delivery side of the pumps.

3.1.2 The arrangement of that main flow filters should be such that to ensure easy cleaning or substitution, without interrupting operation.

3.1.3 With automatic filters, by-pass systems can be approved by the Society if simplex filters in accordance with 3.1.4 are fitted downstream. By-pass systems are not permitted for switch-over duplex filters.

3.1.4 Where simplex filters are used after the main filters the simplex filters are normally to be provided with a by-pass and a differential pressure alarm.

3.1.5 On main engines the lubricating oil for which is supplied from the engine oil sump and which have rated power less than 220 kW the use of simplex filters is permitted only if the latter are equipped with a pressure alarm and can be substituted during operation.

3.2 Exhaust systems

3.2.1 Exhaust gas lines are to be fitted with expansion compensators.

3.2.2 The exhaust gas lines of main and auxiliary engines are to be fitted with suitable silencers.

3.2.3 The surface temperature of the exhaust gas lines should normally not to exceed 220°C. This may be obtained by using proper insulation or cooling means.

3.2.4 Where lagging covering the exhaust piping system including flanges is oil-absorbing or may permit penetration of oil, the lagging is to be encased in sheet metal or equivalent.

3.2.5 Where the exhaust is led overboard near the waterline, means are to be provided to prevent water from being siphoned back to the engine. Where the exhaust is cooled by water spray, the exhaust pipes are to be self-draining overboard.

3.2.6 Where the exhausts of two or more engines are led to a common silencer or exhaust gas-heated boiler or economizer, an isolating device is to be provided in each exhaust pipe.

3.2.7 In two stroke engines with exhaust gas turbo-blowers operating on the impulse systems, due care is to be taken for preventing broken piston rings entering the turbine casing.

SECTION 4 Tests and Trials

4.1 Mass production of internal combustion engines

4.1.1 Definition of mass production

a) Mass production may be defined, in relation to construction of marine engines for main and auxiliary purposes, as that machinery which is produced:
1. in quantity under strict quality control of material and parts according to a programme agreed by the Society;
2. by the use of jigs and automatic machines designed to machine parts to close tolerances for interchangeability, and which are to be verified on a regular inspection basis;
3.
a. by assembly with parts taken from the stock and requiring little or no fitting of the parts and which is subject to:
   - bench tests carried out on individual engines on a program basis;
   - appraisal by final testing of engines selected at random after bench testing.

b) It should be noted that all castings, forgings and other parts for use in the foregoing machinery are also to be produced by similar methods with appropriate inspection.
c) The specification for machinery produced by the foregoing method must define the limits of manufacture of all component parts. The total production output is to be certified by the Manufacturer and verified as may be required, by the inspecting authority.

4.1.2 Mass production of internal combustion engines; procedure for inspection

a) Field of application

The following procedure applies to the inspection of mass produced internal combustion engines having a bore not exceeding 300 mm.

b) Procedure for approval of mass production

1. Request for approval - documents to be submitted

Upon requesting approval for mass production of a type of internal combustion engine, the Manufacturer must submit all the necessary data concerning this type of engine:

- drawings,
- technical specifications of the main parts,
- operation and maintenance manuals,
- list of subcontractors for the main parts.

2. Examination of the manufacturing processes and quality control procedures

The Manufacturer will supply full information regarding the manufacturing processes and quality control procedures applied in the workshops. These processes and procedures will be thoroughly examined on the spot by the Surveyors. The examination will specially concern the following points:

- organization of quality control systems,
- recording of quality control operations,
- qualification and independence of personnel in charge of quality control.

3. Type test

A running test of at least 100 hours duration will be carried out on an engine chosen in the production line. The program of this test is examined specially for each case. At the end of the test, the main parts of the engine will be disassembled and examined. Omission of the test for engines of well known type will be considered.

4. Validity of approval

The Society reserves the right to limit the duration of validity of the approval. The Society must be kept informed, without delay, of any change in the design of the engine, in the manufacturing or control processes or in the characteristics of the materials.

c) Continuous review of production

1. Access of Surveyors to the Workshops

The Society Surveyors must have free access to the Workshops and to the Control Service premises and files.

2. Survey of production.
   - Inspection and testing records are to be maintained to the satisfaction of the Surveyor.
   - The system for identification of parts is to be approved.
   - The Manufacturer must give full information about the quality control of the parts supplied by subcontractors, for which approval may be required. The Society reserves the right to apply direct and individual inspection procedures for parts supplied by subcontractors when deemed necessary.
3. Individual bench test.

The Society may require that a bench test be made under supervision of the Surveyor.

d) Compliance and inspection certificate

For every engine liable to be installed on a ship classed by the Society, the Manufacturer is to supply a statement certifying that the engine is identical to the one which underwent the tests specified in (b).3 and give the inspection and test result. This statement is to be made on a form agreed with the Society. Each statement bears a number which is to appear on the engine. A copy of this statement is to be sent to the Society.

4.1.3 Mass production of internal combustion engines; type test conditions

a) Application

The following test conditions are to be applied to a type test of internal combustion engines for mass production of which the Maker has requested approval. Omission or simplification of the type test may be considered for engines of well-known type.

b) Choice of engine tested

The choice of the engine to be tested, from the production line, is to be agreed with the Society.

c) Duration and program of tests

The duration and program of tests is in principle as follows:

1. 80h at rated output.
2. 8h at 110% overload.
3. 10h at partial loads ($\frac{1}{4}, \frac{1}{2}, \frac{3}{4}$ and $\frac{9}{10}$ of rated output).
4. 2h at intermittent loads.
5. Starting tests.
6. Reverse running of direct reversing engines.
7. Testing of regulator - overspeed device - lubricating oil system failure alarm device.
8. Testing of the engine with turbocharger out of action when applicable.
9. Testing of minimum speed for main propulsion engines and the idling speed for auxiliary engines.

The tests at the above-mentioned outputs are to be combined together in working cycles which are to be repeated subsequently with the whole duration within the limits indicated. The overload is to be alternately carried out with:

- 110% of rated output and 103% rpm.
- 110% of rated output and 100% rpm.

For prototype engines, the duration and programme of tests are to be specially agreed with the Society.

d) Conditions of tests

The following particulars should be recorded:

1. ambient air temperature,
2. ambient air pressure,
3. atmospheric humidity,
4. external cooling water temperature,
5. fuel and lubrication oil characteristics.

e) Measurements and recordings

1. In addition to those mentioned in (d), the following at least are to be measured or recorded:

- engine r.p.m.,
- brake horsepower,
- torque,
- maximum combustion pressure,
- indicated pressure diagrams where practicable,
- exhaust smoke (with an approved smoke meter),
- lubricating oil pressure and temperature,
- cooling water pressure and temperature,
- exhaust gas temperature in exhaust manifold,
- and, where facilities are available, from each cylinder;

2. For supercharged engines

- r.p.m. of turbocharger,
- air temperatures and pressures fore and after turboblower and charge,
- cooler,
- exhaust gas temperature and pressures fore and after turbine charge, charge air cooler, cooling water inlet temperature.

f) Examination after test

After the type test, the main parts and especially those subject to wear, are to be disassembled and examined.

NOTES:

1. For engines that are to be type approved for different purposes (multi-purpose engines), and that have different performances for each purpose, the programme and duration of test will be modified to cover the whole range of the engine performance taking into account the most severe values.
2. The rated output for which the engine is to be tested is the output corresponding to that declared by the manufacturer and agreed by the Society, i.e. actual maximum power which the engine is capable of delivering continuously between the normal maintenance intervals stated by the manufacturer at speed and under the stated ambient conditions.

4.1.4 Mass production of engines; mass produced exhaust driven turboblowers

a) Field of application

The following procedure applies to the inspection of exhaust driven turboblowers which are manufactured on the basis of mass production methods and for which the maker has requested the approval.

b) Procedure of approval

1. Requested for approval: documents to be submitted

When the manufacturer of turboblowers built on the basis of mass production methods applies for a simplified method of inspection, the following documentation must be submitted in triplicate:

- cross-sectional drawings with main dimensions,
- drawings with necessary dimensions and material specifications as well as welding details of the rotating parts (shaft, wheels and blades),
- technical specifications including maximum operating conditions (maximum permissible r.p.m. and maximum permissible temperature),
- list of main current suppliers and subcontractors for rotating parts,
- operation and maintenance manuals.

2. Material and quality control

The manufacturer will supply full information regarding the control organization as well as the inspection methods, the way of recording and proposed frequency, and the method of material testing of important parts. These processes and procedure will be thoroughly examined on the spot by the Surveyors.

3. Type test

The type test is to be carried out on a standard unit taken from the assembly line and is to be witnessed by the Surveyor. Normally the type test is to consist of a hot running test of one hour's duration at maximum permissible speed and maximum permissible temperature. After the test the turboblower is to be opened up and examined.

NOTES:

1. The performance data which may have to be verified are to be made available at the time of the type test.
2. For manufacturers who have facilities for testing the turbo blower unit on an engine for which the turboblower is to be type approved, substitution of the hot running test by a test run of one hour's duration at overload (110% of the rated output) may be considered.

4. Validity of approval

The Society reserves the right to limit the duration of validity of approval. The approval will be invalid if there are any changes in the design, in the manufacturing or control processes or in the characteristics of the materials which have not been approved in advance by the Society.

c) Continuous inspection of individual units

1. Inspection by the Surveyor

The Surveyors must have the right to inspect at random the quality control measures and to witness the under mentioned tests as deemed necessary, as well as to have free access to all control records and subcontractors certificates.

2. Testing of individual units

Each individual unit is to be tested in accordance with .4, .5, .6 and .7 by the maker who is to issue a final certificate.

3. Identification of parts

Rotating parts of the turbo blower are to be marked for easy identification with the appropriate certificate.

4. Material tests

Material tests of the rotating parts are to be carried out by the maker or his subcontractor in accordance with the Society's approval. The relevant certificate is to be produced and filed to the satisfaction of the Surveyor.

5. Pressure tests

The cooling space of each gas inlet and outlet casings is to be hydraulically tested at pressure of either 0,4 N/mm, (4 bar) or 1,5 times the maximum working pressure, whichever is the greater.

6. Balancing and overspeed test

Each shaft and bladed wheel as well as the complete rotating assembly has to be individually dynamically balanced in accordance with the approved procedure for quality control. All wheels (impellers and inducers) have to undergo an overspeed test for 3 minutes at 20% over the maximum speed at room temperature or 10% over the maximum speed at working temperature. If each forged wheel is individually controlled by an approved nondestructive examination method no overspeed test may be required except for wheels of the type test unit.

7. A mechanical running test of each unit for 20 minutes at maximum speed has to be carried out.

NOTE:

1. Subject to the agreement of the Society, the duration of the running test may be reduced to 10 minutes provided that the manufacturer is able to verify the distribution of defects established during the running tests on the basis of a sufficient number of tested turbochargers. For manufacturers who have facilities in their Works for testing the turboblowers on an engine for which the turboblower is intended, the bench test may be replaced by a test run of 20 minutes at overload (110% of the rated output) on this engine.

d) Compliance and certificate

For every turboblower unit liable to be installed on an engine intended for a ship classed by the Society, the Manufacturer is to supply a statement certifying that the turboblower is identical with the one that underwent the tests specified in (b).3 and that prescribed tests were carried out. Results of these tests are to be also stated. This statement is to be made on a form agreed with the Society and a copy is to be sent to the Society. Each statement bears a number which is to appear on the turboblower.

NOTE:

1. In general, the pressure tests are to be carried out as indicated. Special consideration will be given where design of testing features may require modification of the test requirements.

4.2 Program for trials of internal combustion engines

4.2.1 Works trials (acceptance test)

The Program for trials has been written on the assumption that after the tests the fuel delivery system will be blocked so as to limit the engines to run at not more than 100% power. Engines, which are to be subjected to trials on the test bed at the manufacture's works and under the Society's supervision according to these Rules, are to be tested in accordance to the scope as specified below. Exceptions to this require the agreement of the Society.

4.2.2 Scope of works trials

For all stages, for which the engine is going to be tested, the pertaining operation values are to be measured and recorded by the engine manufacturer. All results are to be compiled in an acceptance protocol to be issued by the engine manufacturer. In each case all measurements conducted at the various load points shall be carried out at steady operating conditions. The readings for 100% power (rated power at rated speed) are to be taken twice at an interval of at least 30 minutes.

a) Main engines driving propellers

1. 100% power (rated power) at rated engine speed n_0: at least 60 min, after having reached steady conditions.
2. 110% power at engine speed $n = 1{,}032 \cdot n_0$: 45 min, after having reached steady conditions. **NOTE:**
   After running on the test bed, the fuel delivery system of main engines is normally to be so adjusted that overload power cannot be given in service.
3. 90% (or normal continuous cruise power), 75%, 50% and 25% power in accordance with the nominal propeller curve.
4. Starting and reversing maneuvers.
5. Testing of governor and independent overspeed protective device.
6. Shut down device.

b) Main engines driving generators for propulsion

The test is to be performed at rated speed with a constant governor setting under conditions of:

1. 100% power (rated power) at rated engine speed: at least 60 min, - after having reached steady conditions
2. 110% power: 45 min, - after having reached steady conditions.
   NOTE: After running on the test bed, the fuel delivery system of diesel engines driving generators must be adjusted so that overload (110%) power can be given in service after installation on board, so that the governing characteristics including the activation of generator protective devices can be fulfilled at all times.
3. 75%, 50% and 25% power and idle run.
4. Start-up tests.
5. Testing of governor and independent overspeed protective device.
6. Shut down device.

c) Engines driving auxiliaries

Test to be performed in accordance with (b).

NOTE:
After running on the test bed, the fuel delivery system of diesel engine driving generators must be adjusted so that overload (110%) power can be given in service after installation on board, so that the governing characteristics including the activation of generator protective devices can be fulfilled at all times.

4.2.3 Inspection of components

Random checks of components to be presented for inspection after the works trials are left to the discretion of the Society.

4.2.4 Parameters to be measured

The data to be measured and recorded, when testing the engine at various load points are to include all necessary parameters for the engine operation. The crankshaft deflection is to be checked when this check is required by the manufacturer during the operating life of the engine.

4.2.5 In addition the scope of the trials may be expanded depending on the engine application.

4.2.6 Shipboard trials (dock and sea trials)

After the conclusion of the running-in programme, prescribed by the engine manufacturer, engines are to undergo the trials as specified below:

a) Scope of sea trials

1. Main propulsion engines driving fixed propellers.
   - At rated engine speed n_0:
     - at least 4 hours, and
     - at engine speed corresponding to normal continuous cruise power: at least 2 hours.
   - At engine speed $n = 1,032 \cdot n_0$: 30 minutes (where the engine adjustment permits, see 4.2.2(a).2).
   - At minimum on-load speed.
   - Starting and reversing manoeuvres.
   - In reverse direction of propeller rotation during the dock or sea trials at a minimum engine speed of $n = 0,7 \cdot n_0$: 10 minutes.
   - Monitoring, alarm and safety systems.

2. Main propulsion engines driving controllable pitch propellers or reversing gears.

1) applies as appropriate. Controllable pitch propellers are to be tested with various propeller pitches.

3. Main engines driving generators for propulsion.

The tests to be performed at rated speed with a constant governor setting under conditions of:

- 100% power (rated power):
  - at least 4 hours, and
  - at normal continuous cruise power: at least 2 hours
- 110% power: 30 minutes
- In reverse direction of propeller rotation during the dock or sea trials at a minimum speed of 70% of the nominal propeller speed: 10 minutes
- Starting manoeuvres
- Monitoring, alarm and safety systems

NOTE:

1. Tests are to be based on the rated electrical powers of the driven generators

4. Engines driving auxiliaries

Engines driving generators or important auxiliaries are to be subjected to an operational test for at least 4 hours. During the test, the set concerned is required to operate at its rated power for an extended period. It is to be demonstrated that the engine is capable of supplying 110% of its rated power, and in the case of shipboard generating sets account shall be taken of the times needed to actuate the generator's overload protection system.

5. The suitability of engine to burn residual or other special fuels is to be demonstrated, if machinery installation is arranged to burn such fuels.

b) In addition, the scope of the trials may be expanded in consideration of special operating conditions, such as towing, trawling etc.

SECTION 5 Engine alignment

5.1 General

5.1.1 The crankshaft alignment is to be checked every time an engine has been aligned on its foundation by measurement of the crank web deflections.

Note is to be taken of:
a) The loading condition of the ship, and
b) The condition of the engine (whether hot or cold).

CHAPTER 3 MAIN PROPULSION SHAFTING

SECTION 1 General

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to normal and accepted types of main shafting. In the present Chapter formulas for determining the diameters for shafting for main propulsion installations are included along with requirements for the design of sternbushes, keys, keyways, couplings, coupling bolts and other relevant parts. Any modification to the diameters determined from the formulas of the present Chapter due to alignment requirements is acceptable.

1.2 Documents for approval

1.2.1 The following plans are to be submitted to the Society for consideration before the commencement of the work:

a) general arrangement of the entire shafting from main engine coupling to propeller,
b) detail drawing of the final gear shaft,
c) detail drawing of the thrust shaft,
d) detail drawing of the internmediate shafting,
e) drawing of the tube shaft, where applicable,
f) drawings of the screwshaft and screwshaft oil gland,
g) drawing of the sternbursh.

1.2.2 The following data are also to be submitted for approval:

h) material specifications,
i) strength calculations,
j) vibration calculations.

1.2.3 The Society reserves the right to ask for any additional information.

SECTION 2 Materials

2.1 Materials for shafts

2.1.1 In the design calculations of shafting, the minimum tensile strength of forgings for shafts is to be taken within the following limits

a) Carbon and carbon-manganesse steel: 400 to 600 N/mm^2.
b) Alloy steel: not exceeding 800 N/mm^2.

2.1.2 Where it is proposed to use alloy steel, details of the chemical composition, heat treatment and mechanical properties are to be submitted for approval.

2.2 Ultrasonic tests

2.2.1 Ultrasonic tests are required on shaft forgings where the diameter is 250 mm or greater.

SECTION 3 Design

3.1 Intermediate shafts

3.1.1 The minimum diameter of an intermediate shaft is not to be less than that calculated from the following formula:

$$d = F \cdot k \cdot \sqrt[3]{\frac{P}{n} \cdot \frac{1}{1-\left(\frac{d_i}{d_o}\right)^4} \cdot \frac{560}{\sigma_B + 160}}$$

where:

d = minimum diameter, mm,
d_i = actual diameter of shaft bore, mm,
d_o = actual outside diameter of shaft, mm. If the bore in the shaft is ≤0.4d_o the expression $1-\left(\frac{d_i}{d_o}\right)^4 = 1{,}0$= may be taken.
k = factor for different shaft design features (intermediate shafts), see 3.1.2,
n = rated speed of intermediate shaft, rpm,
P = rated power of the main engine, kW,
σ_B = tensile strength of the shaft material taken for calculation, N/mm².
F= 95 for intermediate shafts in turbine installation, diesel installations with hydraulic (slip type) couplings, electric propulsion installations,
= 100 for all other diesel installations and all propeller shafts

3.1.2 k-factors for different shaft design features (intermediate shafts).

a.

k-factors						
for intermediate shafts with					for thrust shafts external to engines	
integral coupling flanges	shrink fit coupling	keyways	radial bores, transverse holes	longitudinal slots	on both sides of thrust collar	in way of axial bearing where a roller bearing is used as a thrust bearing
1	2	3	4	5	6	7
1,0 (1)	1,0	1,10 (2)	1,10 (3)	1,20 (4)	1,10	1,10

NOTES:

1. Filet radii not less than 0,08·d (see 3.7).
2. After a length of not less than 0,2·d from the end of the keyway the shaft diameter may be reduced to the diameter calculated with k = 1,0.
3. Diameter of bore not more than 0,3·d.
4. Length of the slot not more than 1,4·d, width of the slot not more than 0,2·d, whereby d is calculated with k = 1,0.

a) The determination of k-factors for shaft design features other than those given above is left to the discretion of the Society.

3.2 Gear quill shafts

3.2.1 The diameter d_q of the quill shaft is to be not less than given by the following formula:

$$d_q = 745 \cdot \sqrt{\frac{P}{n \cdot \sigma_B}}, mm$$

where:

P, n are as defined in Chapter 1, SECTION 3, 3.6,

σ_B= specified minimum tensile strength of the material, in N/mm² but is not to exceed 1100 N/mm².

3.3 Final gear wheel shafts

3.3.1 The diameter of the shaft at the final wheel and the adjacent journals is to be greater than 1,15 times that required for the intermediate shaft, where there is only one pinion geared into the final wheel, or where there are two pinions which are set to subtend an angle at the centre of the shaft of less than 120 degrees.

3.3.2 The diameter of the shaft at the final wheel and the adjacent journals is to be greater than 1,10 times that required for the intermediate shaft, where there are two pinions geared into the final wheel opposite, or nearly opposite, to each other.

3.3.3 In 3.3.1 and 3.3.2, abaft the journals, the shaft may be gradually tapered down to the diameter required for an intermediate shaft determined according to 3.1 where σ_B is to be taken as the specified minimum tensile strength of the final wheel shaft material, in N/mm².

3.4 Thrust shafts

3.4.1 The diameter at the collars of the thrust shaft is to be not less than that required for the intermediate shaft as follows from 3.1 with a k-factor value of 1,10.

3.4.2 Outside a length equal to the thrust shaft diameter from the collars, the diameter may be gradually reduced to that required for the intermediate shaft with a k-factor value of 1,0.

3.4.3 In the above calculations σ_B is to be taken as the minimum tensile strength of the thrust shaft material, in N/mm².

3.5 Propeller shafts

3.5.1 The minimum diameter of the protected forged steel propeller shaft is not to be less than that calculated from the following formula

$$d_p = 100 \cdot k \cdot \sqrt[3]{\frac{P}{n} \cdot \frac{560}{\sigma_B + 160}}$$

where:

d_p = minimum diameter, mm,

k = factor for different shaft design features (intermediate shafts), see 3.1.2,
n = rated speed of intermediate shaft, rpm,
P = rated power of the main engine, kW,
σ_B = tensile strength of the shaft material taken for calculation, N/mm^2.

3.5.2 In general, the tensile strength of the steel used shall be between 400 and 800 N/mm^2. For the calculation of the diameter, σ_B is not to be taken as greater than 600 N/mm^2.

3.5.3 In general, the part of the propeller shaft located forward of the forward stern tube seal may be gradually reduced to the diameter of the intermediate shaft.

3.5.4 k-factors for different shaft design features (propeller shafts) - see 3.5.1.

a)

1. k = 1,22 for propeller shafts
   - where the propeller is keyless fitted onto the propeller shaft taper by an approved shrinkage method or
   - where the propeller is attached to an integral propeller shaft flange and
   - where the propeller shaft is oil lubricated and provided with approved type of oil sealing glands or
   - where the shaft is fitted with a continuous liner;
2. k = 1,26 for propeller shafts
   - where the propeller is keyed onto the propeller shaft taper by an approved method and
   - where the propeller shaft is oil lubricated and provided with approved type of oil sealing glands or
   - where the shaft is fitted with a continuous liner.

The above values of k apply to the portion of propeller shaft between the forward edge of the aftermost shaft bearing and the forward face of the propeller boss or, if applicable, the forward face of the propeller shaft flange, subject to a minimum of 2,5·dp. The determination of k-factors for shaft design features other than these given above is to be especially considered.

b) k = 1,15 to the portion of propeller and tube shafts between the forward edge of the forward stern tube seal and the forward edge of the aftermost shaft bearing.

3.5.5 The diameter of unprotected propeller shafts and tube shafts of corrosion resistant materials, in general is not to be less than that calculated from the following formula:

$$d_{np} = 930\sqrt[3]{\frac{P}{n} \cdot \frac{1}{\sigma_B}}$$

where:

d_{np} = minimum diameter, mm,
n = rated speed of intermediate shaft, rpm,
P = rated power of the main engine, kW,
σ_B = tensile strength of the shaft material taken for calculation, N/mm^2.

Propeller and tube shafts having an actual minimum diameter less than the above will be subject to special consideration.

3.6 Hollow shafts

3.6.1 Where there are central holes in the tube and screw shafts, the outside diameters of the shafts are to be greater than:

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

where:

d = Rule size diameter of solid shaft, mm,
d_i = diameter of central hole, mm
d_o = outside diameter, mm.

Where the diameter of the central hole does not exceed 0,4 times the outside diameter, no increase over Rule size is required.

3.7 Coupling flanges

3.7.1 For intermediate, thrust and propeller shaft couplings having all fitted coupling bolts, the coupling bolt diameter is to be not less than that given by the following formula

$$d_b = 0.65 \cdot \sqrt{\frac{d^3 \cdot (T + 160)}{i \cdot D \cdot T_b}}$$

where:

d_b = diameter of fitted coupling bolt, mm,
d = Rule diameter, i.e. minimum required diameter of intermediate shaft made of material with tensile strength T, taking into account ice strengthening requirements where applicable
i = number of fitted coupling bolts,
D = pitch circle diameter of coupling bolts, mm,
T = tensile strength of the intermediate shaft material taken for calculation, N/mm^2,
T_b = tensile strength of the fitted coupling bolts material taken for calculation, N/mm^2

while: T ≤ Tb ≤ 1,7·T, but not higher than 1000 N/mm^2.

3.7.2 The design of coupling bolts in the shaftline other than that covered by 3.7.1 are to be considered and approved by the Society.

3.7.3 For intermediate shafts, thrust shafts and inboard end of propeller shafts the flange is to have a minimum thickness of 0,20 times the Rule diameter d of the intermediate shaft of the thickness of the coupling bolt diameter calculated for the material having the same tensile strength as the corresponding shaft, whichever is greater. Special consideration will be given by the Society for flanges having non parallel faces, but in no case is the thickness of the flange to be less than the coupling bolt diameter.

3.7.4 Fillet radii at the base of the flange should in each case be not less than 0,08 times the actual shaft diameter. Fillets are to have a smooth finish and should not be recessed in way of nuts and bolt heads. The fillet may be formed of multiradii in such a way that the stress concentration factor will not be greater than that for a circular fillet with radius 0,08 times the actual shaft diameter.

3.8 Bronze or gunmetal liners on shafts

3.8.1 The thickness, of liners fitted on screwshafts or on tube shafts, in way of the bushes, is to be greater than:

$$t = \frac{D + 230}{32}, mm$$

where:

t = thickness of the liner, mm,
D = diameter of the screwshaft or tube shaft under the liner, mm.

3.8.2 The thickness of a continuous liner between the bushes is to be not less than 75% of t, where t is given in 3.8.1.

3.8.3 Normally, continuous liners should be cast in one piece. Where this is impracticable they are to be built welded together by using leed-free electrodes or filler rods. The weldings are to be to the Surveyor's satisfaction.

3.8.4 Due care is to be taken in order to ensure the water-tightness of the part of the shaft between the after end of the liner and the propeller boss.

3.8.5 The composition of the gunmetal of each length forming a butt welded liner should be such that the lead content is not to exceed 1%.

3.8.6 The use of pins for securing the liners is not allowed. Liners are to be shrunk on, or forced on, to the shafts by hydraulic pressure.

3.8.7 Every continuous liner or length of liner is to be tested by hydraulic pressure to 2,0 bar after rough machining.

3.9 Keys and keyways

3.9.1 The keyways in the propeller boss and cone of the screwshaft are to be provided with a smooth fillet at their bottom. The keys should be round or sled-runner ended. The edges at the top of the keyways are also to be smooth. The forward end of the keyway is to be so cut in the shaft as to give a gradual rise from the bottom of the keyway to the surface of the shaft.

3.9.2 In general, due care is to be taken for the reduction of the stress concentration as far as practicable.

3.9.3 The key is to fit tightly and safely in the keyway. To this purpose, two screwed pins are to be provided for securing the key in the keyway, and the forward pin is to be placed at least one-third of the length of the key from the end. The depth of the tapped holes for the screwed pins is not to exceed the pin diameter.

3.9.4 The distance between the top of the cone and the forward end of the key way is to be not less than 0,2 of the diameter of the screwshaft at the top of the cone.

3.9.5 The key is to be of sufficient size to transmitt the full torque of the shaft.

3.10 Sternbushes

3.10.1 Oil lubricated bearings of white metal

a) The length of white metal lined bearings is to be not less than 2,0 times the rule diameter of the shaft in way of the bearing.
b) The length of the bearing may be less provided the nominal bearing pressure is not more than 8 bar as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft bearing devided by the projected area of the shaft. However, the minimum length is to be not less than 1,5 times the actual diameter.

3.10.2 Oil lubricated bearings of synthetic rubber, reinforced resin or plastic materials

a) For bearings of synthetic rubber, reinforced resin or plastics materials which are approved for use as oil lubricated stern bush bearings, the length of the bearing is to be not less than 2,0 times the rule diameter of the shaft in way of the bearing.
b) The length of bearing may be less provided the nominal bearing pressure is not more than 6 bar as determined by static bearing reaction calculation taking into account shaft and propeller weight which is deemed to be exerted solely on the aft being devided by the projected area of the shaft. However, the minimum length is to be not less than 1,5 times the actual diameter. Where the material has proven satisfactory testing and operating experience, consideration may be given to an increased bearing pressure.

3.10.3 Water lubricated bearings of lignum vitae.

Where the bearing comprises staves of wood (known as lignum vitae), the length of the bearing is to be not less than 4,0 times the rule diameter of the shaft in way of the bearing.

NOTE:
1. Lignum vitae is the generic name for several dense, resinous hardwoods with good lubricating properties. The original high quality Lignum Vitae is almost unobtainable and other types of wood such as Bulnesia Sarmiento (or Palo Santo or Bulnesia Arabia) are commonly used now.

3.10.4 Water lubricated bearings of synthetic material

a) Where the bearing is constructed of synthetic materials which are approved for use as water lubricated stern bush bearings such as rubber or plastics the length of the bearing is to be not less than 4,0 times the rule diameter of the shaft in way of the bearing.
b) For a bearing design substantiated by experiments to the satisfaction of the Society consideration may be given to a bearing length not less than 2,0 times the rule diameter of the shaft in way of the bearing.

3.10.5 For bearings of cast iron and bronze which are oil lubricated and fitted with an approved oil sealing gland, the length of the bearing is to be not less than 4 times the diameter required for the screwshaft.

3.10.6 The length of the grease lubricated bearings is to be not less than 4 times the diameter required for the screwshaft.

3.10.7 Where the shaft diameter is greater than 360 mm and bearings lined with lignum vitae are used forced water lubrication is required. Where bearings lined with rubber or plastics are used forced water lubrication is always required.

3.10.8 Oil sealing glands are to be of an approved type and capable of operating under the various sea water temperatures it may be subject to in service. In particular, in ships classed for unrestricted service oil sealing glands must be capable of accommodating the effects of differential expansion between hull and line of shafting in sea temperatures ranging from arctic to tropical.

3.10.9 Where lubrication is made by means of gravity, the lubricatiing oil tank is to be located above the load waterline and provided with a low level alarm.

3.10.10 Where sternbush bearings are oil lubricated, means are to be provided for cooling the lubricating oil.

3.11 Vibration and alignment

3.11.1 For the requirements for torsional, axial and lateral vibration, and for alignment of the shafting, see Part 5, Chapter 6 of the Society's "Rules and Regulations for the Classification and Construction of Steel Ships".

CHAPTER 4 PROPELLERS

SECTION 1 General

1.1 Application

1.1.1 The requirements of this part apply to propellers which exceed 1.5 m in diameter.

1.1.2 For propellers which do not exceed 1.5 m in diameter and are part of a manufacturer's standard product line, neither the Surveyor's attendance for material testing and inspection nor the design review will be required.

1.2 Documents for Approval

1.2.1 The following plans and particulars are to be submitted:

a) propellers cast in one piece
b) blades, bolts and hub for built and controllable pitch propellers
c) blade bolt pretensioning and procedure
d) pitch control mechanism
e) data and calculations for fitting of propeller to the shaft.

1.2.2 The plans are to give full details of scantlings and arrangement, as well as, material specification and heat treatment. The manufacturing tolerance class (ISO 484/1/2) is also to be specified on the propeller drawings.

1.2.3 Where the propeller is fitted to the screwshaft without the use of a key, plans of the following items are to be submitted:

a) boss
b) tapered end of screwshaft
c) propeller nut
d) sleeve, where applicable

1.2.4 Where a sleeve is fitted, details of the proposed type of material and mechanical properties are also to be submitted.

SECTION 2 Materials

2.1 Castings

2.1.1 Castings for propellers and propeller blades are to comply with the requirements of the Society's Rules for Materials. The specified minimum tensile strength is to be not less than stated in Table 2.2.1.

2.1.2 For materials not included in Table 2.2.1, details of the chemical composition, mechanical properties and density are to be submitted for approval.

SECTION 3 Design

2.2 3.1 Calculation of minimum blade thickness

2.2.1 The rules mentioned in the present section apply to propellers of normal design for single and multiscrew propulsion.

2.2.2 The thickness tb of the propeller blades at 25% radius for propellers cast in one piece, 35% radius for propellers with separate cast blades is not to be less than:

Table 2.2.1:

Materials	**Special minimum tensile strength (N/mm^2)**	**Density (g/m^3)**	**Allowable stress (N/mm^2)**
Grey cast iron	250	7.2	17.2
Shheroidal or nodular graphite cast iron	400	7.3	20.6
Carbon and low alloy steels	400	7.9	20.6
13% chromium stainless steels	500	7.7	41
Chromium – nickel austenitic stainless steel	450	7.9	41
Grade Cu 1 ▪ Managanese bronze (high tensile brass)	440	8.3	39
Grade Cu 2 ▪ Ni – Managanese bronze (high tensile brass)	440	8.3	39
Grade Cu 3 ▪ Ni – Aluminium bronze	590	7.6	56
Grade Cu 4 ▪ Ni – Aluminium bronze	630	7.5	46

a) fixed- pitch propellers

$$t_{0.25} = k_1 \cdot \sqrt{\frac{A \cdot P}{C \cdot R \cdot N}} \pm 1.72 \cdot \frac{B \cdot K}{C},$$

where:

$$A = 1.0 + \frac{6}{p_{0.70}} + 4.3 \cdot p_{0.25}$$
$$B = \frac{4300 \cdot w \cdot a}{N} \cdot \left(\frac{R}{100}\right)^2 \cdot \left(\frac{D}{20}\right)^3$$
$$C = (1 + 1.5 \cdot p_{0.25}) \cdot (W \cdot f - B)$$

b) controllable-pitch propellers

$$t_{0.35} = k_2 \cdot \sqrt{\frac{A \cdot P}{C \cdot R \cdot N}} \pm 1.09 \cdot \frac{B \cdot K}{C},$$

where:

$A = 1.0 + \frac{6}{p_{0.70}} + 3 \cdot p_{0.35}$
$B = \frac{4900 \cdot w \cdot a}{N} \cdot \left(\frac{R}{100}\right)^2 \cdot \left(\frac{D}{20}\right)^3$
$C = (1 + 0.6 \cdot p_{0.35}) \cdot (W \cdot f - B)$
$t_{0.25}$= thickness at the 25% radius, mm
$t_{0.35}$= thickness at the 35% radius, mm
k_1 = 1067.
k_2 = 857.
P = power at rated speed, kW.
R = revolution at rated speed, rpm.
N = number of blades.
$p_{0.25}$= pitch at 25% radius divided by propeller diameter.
$p_{0.35}$= pitch at 35% radius divided by propeller diameter, corresponding to the design ahead c conditions.
$p_{0,70}$= pitch at 70% radius divided by propeller diameter, corresponding to the design ahead conditions.
W = expanded width of a cylindrical section at the 0,25 or 0,35 radius, mm.
a = expanded blade area divided by the disc area.
D = propeller diameter, m.
K = rake of the propeller blade in mm/m multiplied by D/2 (with forward rake, use minus sign in equation; with aft rake, use plus sign).
f,w = material constants from the Table 2.2.2.

Table 2.2.2:

Materials	**f**	**w**
Austenitic Stainless Steel	2.10	7.75
Cast steel	2.10	8.30
Manganese Bronze	2.10	8.30
Ni - Manganese Bronze	2.25	8.00
Ni - Aluminium Bronze	2.62	7.50

2.2.3 The fillet radius between the root of a blade and the boss of a propeller is to be not less than the Rule thickness of the blade or equivalent at this location. Composite radiused fillets or elliptical fillets which provide a greater effective radius to the blade are acceptable and are to be preferred.

2.2.4 Where the design of a propeller has been based on analysis of reliable wake survey data in conjunction with a detailed fatigue analysis and is deemed to permit scantlings less than required by 3.1.2 and also for propellers of unusual design, or where the propeller is intended for more than one operating regime, such as towing or trawling, a detailed stress computation for the blades is to be submitted for consideration.

SECTION 4 Fitting of Propeller

4.1 Propeller Boss

4.1.1 The propeller boss is to be a good fit on the screwshaft cone. The forward edge of the propeller bosses is to be rounded to about a 6 mm radius. In the case of keyed propellers,the length of the forward fitting surface is to be about one diameter and, where the fitting is by means of a hydraulic nut, the requirements of 4.2, where appropriate, are applicable.

4.2 Final Fitting of Keyless Propellers

4.2.1 After verifying that the propeller and shaft are at the same temperature and the mating surfaces are clean and free from oil or grease, the propeller is to be fitted on the shaft to the satisfaction of the Surveyors. The propeller nut is to be securely locked to the shaft.

4.2.2 Permanent reference marks are to be made on the propeller boss,nut and shaft to indicate angular and axial positioning of the propeller. Care is to be taken in marking the inboard end of the shaft taper to minimize stress raising effects.

SECTION 5 Tests

5.1 Balancing

5.1.1 The finished propeller and the blades of controllable pitch propellers are required to undergo static balancing.

5.2 Testing

5.2.1 Fixed pitch propellers, controllable pitch propellers and controllable pitch propeller systems are to be presented to the Society for final inspection and verification of the dimensions. In addition, controllable pitch propeller systems are required to undergo pressure, tightens and operational tests. The Society reserves the right to require non-destructive tests to be conducted to detect surface cracks or casting defects. With regard to the assessment and the repair of defects on propellers, see the “Rules for the Classification and Construction of Steel Ships”, Part 2, Chapter 7, SECTION 1, 1.9.

CHAPTER 5 PIPING SYSTEMS

SECTION 1 General

1.1 Application

1.1.1 This Chapter presents the general requirements, which should govern the materials selection, the design and construction of piping systems installed on craft not exceeding 24 m Rule length. Where craft have a Rule length exceeding 24 m the requirements of Part 5 of the Rules and Regulations for the Classification and Construction of steel ships are to be complied with, where applicable.

1.1.2 Piping arrangement of fishing vessels will satisfy relevant requirements of Torremolinos International Convention for the safety of Fishing Vessels.

1.2 Definitions

1.2.1 Piping is defined to include the following components:

a) pipes,
b) expansion elements,
c) valves and fittings,
d) flanges and other pipe connections,
e) hangers and supports,
f) flexible hoses,
g) pump housings.

1.2.2 A piping system is defined to include piping, as well as components in direct connection to the piping such as pumps, heat exchangers, starting air vessels, evaporators, tanks, etc. with the exception of main components such as diesel engines, reduction gears etc.

1.2.3 The maximum allowable working pressure of a piping system component is the maximum pressure which the component can sustain in continuous use with regard to the materials used, design, working temperature and undisturbed operation.

1.2.4 The design pressure is the maximum allowable working pressure for which a component or a piping system is designed and is not to be less than the pressure at which the safety equipment will become active (e.g. activation of safety valves, opening of return lines of pumps, operating of over pressure safety arrangements, opening of relief valves) or at which the pumps will operate against closed valves.

1.2.5 The design temperature is the maximum temperature of the internal fluid and is not to be taken less than 50°C.

1.3 Documentation

1.3.1 The following plans in triplicate are to be submitted for approval:

a) General arrangement of engine room.
b) Sanitary system.
c) Bilge system. Ballast system.
d) Vent, sounding and overflow pipes.
e) Fuel-oil fillings, transfer and service systems.
f) Lubricating oil-systems.
g) Fresh water service systems.
h) Fire-main and fire extinguishing systems.
i) Steering gear piping systems.
j) Starting-air piping.
k) Exhaust systems.

1.3.2 The plans are to include the following particulars:

a) Outside diameter and wall thickness of pipes.
b) Materials to be used in pipes, valves and fittings.
c) Pump type and capacity.
d) Type of flexible hoses and expansion elements.
e) Maximum working pressure.
f) Maximum temperature.

SECTION 2 Materials

2.1 Material requirements

2.1.1 Materials to be used in construction of piping systems are to be manufactured and tested in accordance with the applicable requirements of Part 2 of the “Rules and Regulations for the Classification and Construction of Steel Ships”.

2.1.2 The materials to be used are to be suitable for the medium and service for which the system is intended. Unless specifically mentioned, all metallic materials with melting point above 900°C may be used.

2.2 Steel piping

2.2.1 Steel pipes are normally to be of seamless drawn material or fabricated with a welding procedure considered by the Society to be equivalent to the seamless one.

2.3 Copper and copper alloy piping

2.3.1 Copper and copper alloy piping shall be of seamless drawn material or other type approved by the Society.

2.3.2 Copper and copper alloys are in general not be used for media having temperature above the following limiting values:

(a) copper and aluminium brass: 200°C
(b) copper nickel: 300°C

Special bronze suitable for high temperature service may be used for media having temperature up to 260°C.

2.3.3 Pipes for starting air are not to be of copper or copper alloys when the outer diameter exceeds 44,5 mm.

2.3.4 Pipes which have been hardened by cold bending are to be suitably heat treated on completion of fabrication and prior to being tested by hydraulic pressure. Copper pipes are to be annealed and copper alloy pipes are to be either annealed or stress relief heat treated.

2.4 Nonmetallic materials

2.4.1 Pipes made from non-metallic materials tested according to an approved specification may be used for the following services:

a) sea cooling water systems,
b) ballast water systems,
c) fresh cooling water system,
d) bilge systems,
e) air and sounding pipes for water ballast tanks and fresh water tanks,
f) pipes for non-essential services not conveying flammable fluids.

2.4.2 Pipes for non-essential services may be of recognised standard for domestic water services.

2.4.3 For ships of special service, e.g. tugs, fire-fighting boats etc. 2.4.1 is applied only after examination of the possible effects of the ship’s service on the piping system under consideration.

SECTION 3 Design principles

3.1 General

3.1.1 Piping systems are normally to be made of rigid pipes. The use of flexible hoses of approved type suitable for their intended use may be accepted in lieu of rigid piping upon special consideration. Pipes and fittings are to be supported in such a way that their weight is not taken by connected machinery or that heavy valves and fittings do not cause large additional stresses in adjacent pipes.

3.1.2 Axial forces due to internal pressure, change in direction or cross-sectional area and movement of the ship are to be taken into consideration when mounting the piping system.

3.1.3 The support of the piping system is to be such that detrimental vibrations will not arise in the system.

3.1.4 Metallic pipes are to be connected by welding or brazing or by detachable connections of approved type.

3.1.5 Plastic pipes are to be connected by an approved method, e.g. welding, gluing or cementing, or by approved detachable connections.

3.1.6 Installations of pipes for water or oil, behind or above electric switchboards is to be avoided as far as possible. If this is impracticable, all detachable pipe joints and valves are to be at the safe distance from the switchboard or well shielded from it.

3.1.7 Water pipes and air and sounding pipes through freezing chambers are to be avoided.

3.2 Operation of valves

3.2.1 Sea suction and discharge valves, bilge valves and valves on the fuel oil and lubricating oil tanks which are situated higher than the double bottom tanks are to be arranged for direct mechanical manual operation. The changeover to manual operation from possible remote-control arrangement is to be simple to execute.

3.2.2 For remotely controlled valves failure in power supply is not to cause:
(a) opening of closed valves
(b) closing of open valves on fuel oil tanks and in cooling water system for propulsion and power generating machinery.

3.2.3 Remotely controlled valves are to be provided with indications for open and closed valve positions at the control station. In cases where possibility of direct manual operation is required in addition to the remote control means of observing the valve position at the valve location is to be provided.

3.3 Direct connections of pipe lengths

3.3.1 Direct connection of pipe lengths may be obtained by: butt-welded joints, socket weld joints, slip-on sleeve welded joints and sleeve threaded joints.

3.3.2 Butt-welded joints shall be of full penetration type with or without provision for a high quality of root side. Joints of this type with special provisions for root side are applicable irrespective of the diameter.

3.3.3 Socket weld fittings are to be of forged steel in accordance with a recognized standard. They may be used with carbon steel pipes not exceeding 60,3 mm outside diameter. They are not to be used in systems involving corrosive service or where fatigue is liable to occur.

3.3.4 Sleeve threaded joints are to be in accordance with a standard recognized by the Society. They are allowed only for subordinate systems (e.g. sanitary and hot water heating systems). Screwed pipe connections and pipe couplings may be used subject to special approval.

3.3.5 Slip-on joints, sleeve threaded joints, socket weld joints and other types of direct connection of pipe lengths may be allowed by the Society in each particular case for small diameter and depending upon the service conditions.

3.4 Flange connections

3.4.1 Flanges may be cut from plates or may be forged or cast. The selection of material is based upon the design temperature. The design pressure helps in determining the appropriate particulars of the flange. Flanges differ in method of attachment to the pipe, that is, whether they are screwed and expanded or welded. Alternative methods of flange attachment may be accepted provided details are submitted for consideration.

3.4.2 The dimensions and materials of flanges and corresponding bolting, and the pressure-temperature rating of bolted flanges in pressure pipelines in accordance with national or other established standards will be accepted.

3.4.3 Acceptable flange connections are described in Part 5, Chapter 8, SECTION 4, 4.2 of the Society's "Rules for the Classification and Construction of Steel Ships".

3.4.4 Welded-on flanges are not to be a tight fit on the pipes. The maximum clearance between the bore of the flange and the outside diameter of the pipe is to be 3 mm, at any point, and the sum of the clearances diametrically opposed is not to exceed 5 mm.

3.5 Required minimum wall thickness

3.5.1 The required minimum wall thickness are not to be less than either those derived by stress analysis or the minimum wall thickness assigned to standard pipe sizes as stated in Table 5.3.1, in the case of steel pipes or in Table 3.5.2, in the case of copper and copper alloy pipes.

3.5.2 The minimum wall thickness, listed in Table 3.5.1 and Table 3.5.2 are the nominal wall thickness and they need no allowance to be made for negative tolerance and reduction in thickness due to bending. The outside diameters and the thickness have been taken from ISO standards. Steel pipes are corresponding to ISO 4200-1985 (E): "Plain end steel tubes, welded and seamless-general tables and dimensions and masses per unit length" For larger diameters, the minimum thickness will be specially considered.

3.5.3 For venting, bilge, ballast, fuel, overflow and sounding pipes as listed Table 5.3.1, provided that they are efficiently protected against corrosion, the thickness may be reduced by not more than 1 mm, at the discretion of the Society.

3.5.4 Protective coatings such as hot-dip galvanising, may be recognised as an effective corrosion protection for steel pipes provided that the preservation of the protective coating during installation is guaranteed.

3.5.5 Pipes made of stainless steel shall have minimum wall thickness determined after special consideration approved by the Society.

3.5.6 The minimum internal diameter for bilge, sounding, venting and overflow pipe shall be:
(a) Bilge pipes: 50 mm
(b) Sounding pipes: 32 mm
(c) Venting and overflow pipes: 50 mm

Table 3.5.1: Minimum wall thickness for steel pipes (mm)

External diameter D (mm)	Pipes in general	Venting overflow and sounding pipes for structural tanks (1)	Bilge ballast and general sea water pipes	Bilge, air, overflow and sounding pipes through fuel tanks and fuel lines through ballast tanks (1, 3)
10.2-12	1.6			
13.5-19.3	1.8			
20	2			
21.3-25	2		3.2	
26.9-33.7	2		3.2	
38-44.5	2	4.5	3.6	6.3
48.3	2.3	4.5	3.6	6.3
51-63.5	2.3	4.5	4	6.3
70	2.6	4.5	4	6.3
76.1-82.5	2.6	4.5	4.5	6.3
88.9-108	2.9	4.5	4.5	7.1
114.3-127	3.2	4.5	4.5	8
113-139.7	3.6	4.5	4.5	8
152.4-168.3	4	4.5	4.5	8.8
177.8	4.5	5	5	8.8
193.7	4.5	5.4	5.4	8.8
219.1	4.5	5.9	5.9	8.8
144.5-273	8	6.3	6.3	8.8
298.5-368	5.6	6.3	6.3	8.8
406.4-457.2	6.3	6.3	6.3	8.8

NOTES:
1. For sounding pipes, except those for cargo tanks with cargo having a flash point less than 60°C, the minimum wall thickness is intended to apply to the part outside the tank.
2. The minimum wall thickness for cargo oil lines and exhaust gas pipes will be subject to special consideration by the Society in each case.

3. The minimum wall thickness for bilge lines and ballast lines through day tanks is to be faced as laying through fuel tanks.

Table 3.5.2: Minimum wall thickness for copper and copper alloy pipes

Outside Diameter	Minimum wall thickness (mm)	
D (mm)	Copper	Copper alloy
8-10	1	0.8
12-20	1.2	1
25-44.5	1.5	1.2
50-76.1	2	1.5
88.9-108	2.5	2
133-159	3	2.5
193.7-267	3.5	3
273-457.2	4	3.5
(470)	4	3.5
508	4.5	4

3.6 Plastic pipes

3.6.1 Minimum wall thickness and acceptable internal pressure of plastic pipes are determined by long term testing of hydraulic pressure strength according to an approved specification.

3.6.2 Evaluation of vacuum and external pressure resistance is necessary for plastic piping. Due to low elasticity modulus the buckling stability may be critical in pipe systems where vacuum or external pressures are to be expected.

3.6.3 Temperature limits and pressure reductions are indicated in Table 3.6.1 and Table 3.6.2. The limits may be extended on basis of acceptable documentation from the pipe manufacturer. The permissible temperatures are stated for long term service. Short periods of marginally higher temperatures may be accepted by case to case considerations.

3.6.4 The Tables are related to water service only. Use for other media shall be considered case by case.

3.6.5 If thermoplastic pipes are to be installed in external areas, the pipes shall either be particularly approved for external use or be protected against ultraviolet radiation.

3.6.6 Plastic pipes are normally made of electrical insulating materials and are as such not acceptable for service in gas hazardous areas. Special qualities can be permitted if they are documented to be electrically conductive (antistatic) according to an approved specification.

3.6.7 The need for expansion elements must be specially considered with respect to the large thermal expansion coefficient of the plastic materials.

3.6.8 Glassfibre reinforced epoxy and polyester pipes are considerably more exposed to damage from impact and local overloading than steel pipes. This must be duly taken into consideration by handling, installation and inspection.

Table 3.6.1: Permissible pressures and temperature limiting values for thermoplastic pipes

Material	Nominal pressure (1) (bar)	Permissible working pressure (bar)						
		-20-0 °C	30 °C	40 °C	50 °C	60 °C	70 °C	80 °C
PVC	10		7.5	6				
	16		12	9	6			
ABS	10	7.5	6					
	16	12	9.5	6				

NOTE:
1. According to recognized standards for water supply on shore.

Table 3.6.2: Permissible pressures and temperature limiting values for glassfibre reinforced epoxy (1) and polyester pipes

Min. heat distortion temp of resin ISO 75 Method A	Nominal pressure PN (2)	Permissible working pressure (bar)							
		-20-30 °C	40 °C	50 °C	60 °C	70 °C	80 °C	90 °C	95 °C
80	10	10	9	7.5	6				
	15	15	14	12	9.5				
	25	16	16	16	15				
100	10	10	10	9.5	8.5	7.5	6		
	16	16	16	15	13.5	11	9.5		
	25	16	16	16	16	16	15		
135	10	10	10	10	10	9.5	8.5	7	6
	16	16	16	16	16	11	13.5	11	9.5
	25	16	16	16	16	16	16	16	16

NOTE:
1. Minimum heat distortion temperature 135.
2. According to recognised standards for marine use.

SECTION 4 Pumps

4.1 General

4.1.1 The following pumps are to be delivered with the Society's certificate:
a) sea-water cooling pumps for main engine,
b) fresh-water cooling pumps for main engine,
c) fuel oil service pumps,
d) fuel injection valve cooling pumps,
e) lubricating oil pumps for main engine and main reduction gear,
f) bilge pumps,
g) ballast pumps,
h) fire pumps and emergency fire pumps.

4.2 Relief valves

4.2.1 Displacement valves are to be fitted with relief valves. For pumps transporting flammable liquids, the discharge from the relief valve is normally to be led back to suction side of the pump.

4.3 Tests

4.3.1 Hydrostatic tests

Pump housings are to be hydrostatically tested at a pressure of 1,5 times the maximum working pressure. However, the test pressure need not exceed the maximum working pressure by more than 70 bar. For centrifugal pumps the maximum pressure head on the head-capacity curve. For displacement pumps the maximum working pressure is not to be taken less than the relief valve opening pressure.

4.3.2 Capacity tests

a) Pump capacities are to be checked with the pump running at design conditions.
b) Capacity test may be dispensed with for pumps produced in series when previous satisfactory tests have been carried out in similar pumps.
c) For centrifugal pumps having capacities less than 1000 m^3/h, the pump characteristic (head - capacity curve) is to be determined for each type of pump. For centrifugal pumps having capacities equal to or greater than 1000 m^3/h, the pump characteristic is to be determined over a suitable range on each side of the design point, for each pump.

SECTION 5 Valves

5.1 General requirements

5.1.1 Drawings and specifications are to be submitted for approval for valves of new type or unconventional design.

5.1.2 Indicators are to be provided to show the opened and closed position of the valve, unless it can be observed in some other way.

5.1.3 Handles in cocks are to be removable only when the cocks are in the closed position.

5.1.4 Welded necks of valve bodies are to be sufficiently long to ensure that the valves are not distorted as result of welding and subsequent heat treatment of the joints.

SECTION 6 Bilge System

6.1 Application

6.1.1 All craft to which these rules apply, shall be provided with satisfactory bilge pumping arrangement for effective draining of any watertight compartment which is not intended for permanent storage of liquid.

6.1.2 The bilge pumping system for crafts intended for passenger transport is to be capable of operation under all possible values of list and trim after sustaining assumed side and bottom damages as follows:

a) Assumed side damaged length anywhere on the periphery of the craft:

1. 0.1 L or 3 meters + 0.03 L, or 11 metres, whichever is the least.
2. Depth of penetration into the craft:
   0,2 B or 5 metres, whichever is less. However, where the craft is fitted with inflated shirts or with non-buoyant side structures, the depth of penetration should be at least 0,12 of the width of the main buoyancy hull or tank structure.
3. The vertical extend of damage should be taken for the full depth of the craft.

b) Assumed bottom damages anywhere on the bottom of the craft as follows:
1. Damage length fore and aft. directions:
   - 0.1 L or 3 metres + 0.03 L, or 11 metres, whichever is the least.
2. Width of damage:
   - 0.2 B or 5 metres, whichever is less, except that in the case of a catamaran or an air-cushion vehicle the damage to the bottom of the bridge deck cross-connecting the hulls or side walls need only be assumed if that structure is submerged with the craft in the undamaged displacement mode. The width of damage in such a case need not be greater than the separation of the hulls or side walls.
3. the depth of penetration into the craft should be:
   - 0.02 B or 0,5 metres, whichever is less.

6.1.3 For twin hull craft the tunnel breadth on water line may be subtracted from the greatest moulded breadth when calculating the depth of penetration into the craft at assumed side damage.

6.2 Bilge pumping arrangement.

6.2.1 At least one suction suitably arranged shall be provided in every compartment.

6.2.2 Efficient arrangements shall be provided whereby water in any watertight compartment may find its way to the suction pipes.

6.2.3 Where drainage from particular compartments are considered undesirable, the provisions for such drainage may be omitted, provided it can be shown by calculations that the safety of the craft will not be impaired.

6.2.4 Every machinery space shall be provided with at least two bilge suctions suitably arranged. The bilge suctions shall be led from readily accessible mudboxes placed wherever practicable above the level of working floor.

6.2.5 The mudboxes shall have straight tailpipes to the bilges and are to be arranged for easy inspection and cleaning.

6.2.6 Every compartment to be served by portable bilge pump shall be arranged with access for easy connection and operation of such pump. The access for portable bilge pumping operation in compartment not arranged with fixed installed bilge suction shall be from a sheltered place.

6.3 Protection against flooding through bilge pipes

6.3.1 The bilge and ballast pumping systems shall be so arranged as to prevent water passing from sea or from water ballast systems into machinery space or any other dry space or from one watertight compartment to another.

6.3.2 The bilge connection to any pump which effects suction from sea or from water ballast spaces shall be made by means of a screw down non-return valve so arranged that ingress of water into the bilge system is prevented. Branch bilge lines are to be connected to main bilge line by closeable non-return valves.

6.3.3 Any bilge pump and bilge main line serving drainage of more than one watertight compartment is to be installed inboard and above the assumed depth of damage into the craft as specified in 6.1.2. Branch bilge pipes are to be fitted with non return valve in the compartment containing the open end.

6.3.4 Where a fixed installed bilge pumping system is arranged in each watertight compartment serving only the compartment where installed, the requirement for installation of such bilge pumping inside the assumed depth of damage may be omitted.

6.4 Number of capacities of bilge pumps

6.4.1 At least two pumps are to be available for bilge pumping from every compartment of which at least one should be reserved solely for bilge pumping duties. Any other pump of suitable output available on board, except for an oil pump, may be used as the second bilge pump.

6.4.2 The pumps may be fixed or portable and they should be power driven unless the output of each pump is less than 1,5 tons per hour.

6.4.3 The output of each pump should in general meet the following formula:

$$Q = 3.75\left(1 + \frac{L}{36}\right)^2$$

where:

Q = output in tons per hour.
L = length of the craft in meters. Length (L) means the length of the craft measured on the design waterline in the displacement mode.

6.4.4 The Society may permit a lesser bilge pump output, but the output of each bilge pump shall in no case be less than:

$$Q = 0.05 \cdot LW,$$

where:

Q = output in tons per hour with a minimum of one (1) ton per hour,
LW = light weight of the craft in tons.

6.4.5 Hand pumps shall be installed above the bulkhead deck.

6.4.6 Internal diameters of bilge lines should not be less than 25 mm. Bilge lines are to be fitted with effective strainers.

6.4.7 All cocks and valves shall have their controls at their place of operation clearly marked and provided with means to indicate whether they are open or closed.’

6.5 Air, sounding and filling pipes.

6.5.1 All compartments and tanks arranged with filling and/or drainage arrangement are to have air pipe and means for ascertaining the level of the liquid.

6.5.2 All tanks containing flammable liquids or which can be pumped up or filled from the sea are to have air pipe extending above the weather deck.

6.5.3 Air pipes from fuel and lubricating oil systems are to be carried up to a position where water cannot enter and so arranged that vapour or overflow cannot be ignited.

6.5.4 All air pipes outlets are to have approved means preventing ingress of water and such arrangement are to be so that the tanks are not exposed to vacuum or pressure exceeding the design pressure or vacuum.

6.5.5 All air pipes carried up to the open air are to extend at least 760 mm above the freeboard deck and 450 mm above the superstructure deck or where carried out through the side of the craft such outlet are wherever practicable to be at least 2300 mm above the waterline. Where these heights may interfere with the operation of the craft, a lower height may be approved by the Society on the condition that satisfactory closing arrangement and other circumstances justify a lower height.

6.5.6 All tanks containing flammable liquids or which can be pumped up or filled from the sea are to have sounding pipe carried up to the open air fitted with screw cap or equivalent. Other approved level indicator or remote sounding arrangement may replace sounding pipe.

6.5.7 Filling pipes to tanks containing flammable liquids shall terminate on the weather deck and shall be so arranged that possible spill cannot escape to the inside of the vessel, but will be collected inside a suitable arranged coaming.

6.5.8 All filling pipes to fuel and lubricating oil tanks are to have screw caps, plugs or similar arrangement preventing water from entering such tanks.

6.5.9 Air pipes for tanks not fitted with overflow pipes are to have a cross sectional area not less than 125% of the filling lines.

6.6 Scuppers and discharges

6.6.1 A sufficient number of scuppers, arranged to provide effective drainage, is to be fitted to all decks.

6.6.2 Scuppers on weather portions of decks and scuppers leading from superstructures or deckhouses not provided with closing appliances are usually to be led overboard.

6.6.3 Scuppers led through the deck or shell are to comply with requirements to material and thickness as given in 6.7.4.

6.6.4 Scupper pipes are to be well stayed to prevent any vibrations. However, sufficient possibility for expansion of the pipes to be provided when necessary.

6.6.5 Scuppers from spaces below the freeboard deck or spaces within closed superstructures may be led to bilges.

6.6.6 Scuppers leading overboard from spaces mentioned in 605 are to comply with the requirements given for discharges. Scuppers from exposed superstructure deck, led through the ship's sides and not having closeable valves, are to have strength as required in 6.7.4.

6.6.7 Discharges led through the shell either from spaces below the freeboard deck or from spaces within superstructures and deckhouses on the freeboard deck, fitted with doors as required in Part 3, Chapter 6, SECTION 1, are to be provided with efficient means for preventing water from passing inboard.

6.7 Fittings on sides and bottom

6.7.1 All sea inlets and discharges are to have easily operable valves of an approved type connected to the side or bottom of the craft by a substantial flange connection or equivalent.

6.7.2 The choice of material combination, dimensioning and corrosion protection of the sea inlet and discharge valves connection to the sides and bottom of the craft is to be so arranged that flooding as a reason of damage of such fitting is avoided.

6.7.3 Exhaust outlets through the side of the craft is to be so arranged that ingress of water into the engine is avoided

6.7.4 The thickness and diameter of piping between hull plating and closeable or non-return valve are to be chosen so as to achieve equivalent strength as the surrounding hull structure. Due regard to be taken to the corrosion resistance of the piping material.

6.7.5 All sea inlet valves and outlet valves fitted below the waterline are to be arranged for direct mechanical closing with the manoeuvring handle situated easily accessible and visible above the waterline. Valve position indicator is to be visible at the manoeuvring stand.

SECTION 7 Machinery piping system and ventilation

7.1 Tank arrangement for fuel and other flammable fluids.

7.1.1 The requirements in this section apply to craft using diesel oil for internal combustion engine units with a flash point but not lower than 43°C. However, fuel with a lower flash point but not lower than 38°C may be used provided suitable precautions are taken against the risk of fire and explosion.

7.1.2 Fuel oil tanks carrying fuel oil with flash point lower than 43°C used for propulsion shall be located in watertight compartments separate from, but adjacent to the engine room in a non-hazardous fire area.

7.1.3 Fuel tanks for emergency diesel engines shall be located on or above the weather deck outside the engine housing or compartment and as close to the engine as practicable.

7.1.4 The fuel oil tanks shall preferably be part of the craft's structure and shall be located (except for double bottom tanks) outside fire hazard area.

7.1.5 For craft constructed or GRP or aluminum alloy, consideration may be given to fuel oil tanks being constructed of same material, but in no case are they to be installed in fire hazard area, nor are they to form part of the boundary to such spaces.

7.1.6 Daily service tanks of steel or equivalent material may be permitted in fire hazard areas. All pipes connected to such tanks below the highest tank liquid level are to be arranged with remote quick-closing valves.

7.1.7 Tanks containing fuel and other flammable liquid may be rectangular or cylindrical in shape, and shall be designed to withstand the maximum head to which they may be subjected in service taking into account the dynamic forces encountered.

7.1.8 All tanks not forming part of the craft's structure shall be securely fastened and shall be arranged so as to be readily inspected or movable for inspection.

7.1.9 All free-standing fuel oil tanks shall be so installed as to provide a free circulation of air around the tanks.

7.1.10 Cylindrical tanks with longitudinal seams shall be arranged horizontally where practicable so that such seams are located as near to the top as possible.

7.1.11 All tanks containing fuel or other flammable fluids are to be separated from passenger, crew and baggage compartments by cofferdams or equivalent.

7.1.12 Tanks containing fuel or other flammable fluids having connections below the highest tank liquid level are to have spill tray so arranged that any spill can be collected and easily removed in order to prevent leakage or spillage to the bilge from detachable piping connections.

7.1.13 No tubular gage glasses or try-rocks should be fitted to the fuel oil tanks

7.2 Piping conveying fuel or other flammable fluids.

7.2.1 Fuel piping should be accessible protected from mechanical damage, be effectively secured against excessive movements and vibration, and so routed that it does not pass through passenger, cargo crew compartments. Flexible fuel pipes should have suitable connections, be resistant to salt, water, oil and vibration, be visible, easily accessible and should not penetrate watertight bulkheads.

7.2.2 Fuel tank filling, vent and drain lines should be of adequate size and terminate in a manner that will not constitute a hazard.

7.2.3 Provision should be made for the management and control of the fuel system from a position readily accessible to the crew. Where gravity tanks are arranged, remote-controlled shut-off valves should be provided at the tank.

7.2.4 Displacement pumps transporting flammable fluids are to be fitted with relief valves. The discharge from the relief valve is wherever practicable to be lead back to suction side of the pump.

7.2.5 Piping conveying fuel and other flammable liquids are not to be carried through passenger, crew and baggage compartments.

7.2.6 All fuel or other flammable liquid piping leading into fire hazard area are to be arranged with shut-off valves located outside the fire hazard area or equivalent arrangement preventing flow of fuel from damaged piping into such area.

7.3 Fuel oil system

7.3.1 The fuel supply to propulsion and essential service auxiliary machinery is to be arranged with water separating/filtering equipment which can be drained or cleaned without interrupting the fuel supply.

7.3.2 For propulsion or auxiliary machinery arranged with two mutual independent engines with sufficient capacity for the manoeuvrability of the craft the requirement of duplicated filtering equipment may be omitted.

7.4 Lubricating oil system

7.4.1 The lubricating oil systems for propulsion and essential service auxiliary machinery are to be arranged with suitable filtering equipment which can be cleaned without interrupting the oil supply to the engine.

7.4.2 The lubricating oil system shall be designed to function satisfactorily when the craft has a permanent list of at least 15°.

7.4.3 Where the size and design of an engine is such that lubrication before starting is not necessary and an attached pump is normally used, no independent auxiliary pump is required.

7.4.4 If the lubrication oil pump is independently driven (electrically driven the number of such lubrication oil pump shall not be less than 2).

7.5 Cooling water systems

7.5.1 Where water is used as cooling medium for propulsion or auxiliary machinery of essential service, the cooling water circulating system is to be arranged so that in the event of failure of a circulating pump an alternative pump is available for same duty.

7.5.2 For propulsion or auxiliary machinery, arranged with two mutual independent engines with sufficient capacity for the manoeuvrability of the craft, having attached sea water cooling pumps the requirements of space pump for such duty may be omitted.

7.5.3 For propulsion or auxiliary machinery having attached fresh water cooling pumps the requirement of spare pump for such duty may be omitted.

7.5.4 The sea water suction shall be provided with strainers which can be cleaned without interrupting the cooling water supply which are needed for the manoeuvrability of the craft.

7.5.5 Seawater cooling systems for the main and auxiliary machinery are normally to be connected to two separate cooling water inlets, preferably on opposite sides of the craft.

7.6 Starting systems

7.6.1 Propulsion and generator engines are to be equipped with starting arrangement of sufficient capacity which can be easily operated without external aid.

7.6.2 The starting arrangement is to have capacity sufficient for starting each engine 6 times without recharging of the power capacity.

7.6.3 Equipment for recharging of the engine starting power capacities as required in 602 is to be available onboard the craft. In the case of pneumatic starting arrangements such recharging is to be possible within one hour. For other types of starting arrangements required recharging time will be considered case by case.

7.7 Machinery space ventilation

7.7.1 A mechanical ventilation system with suitable weather deck inlets and outlets including dampers shall be provided for the machinery space.

7.7.2 Calculated air quantity required shall be based on the sum of the air demanded for diesel engines and boilers as well as the requirements for exhaustion of heat emitted from diesel engines, electrical equipment, boilers, exhaust pipes and tanks etc. However, in no case shall air supply be less than total sum of needed combustion air plus 50%.

7.7.3 The air ventilation system should be designed so as to keep a slight positive air pressure in the machinery space while operating at normal condition.

7.7.4 The temperature rise (maximum difference between exhaust and supply air) should normally not exceed 10°C assuming maximum ambient air temperature.

7.7.5 The air system should be distributed and balanced in such way as to provide an atmosphere which is agreeable to the personnel, machinery and equipment throughout the space.

7.7.6 Air should not discharge directly on insulated piping or electrical equipment nor should it be necessary that air be directed at any equipment in order for it to function properly.

7.7.7 Fire dampers shall be fitted to all inlets and outlets

CHAPTER 6 STEERING GEAR

SECTION 1 Plans and specifications

1.1 Documents for approval

1.1.1 Before starting construction, all relevant plans and specifications are to be submitted to the Society for approval.

SECTION 2 Definitions

2.1 Main definitions

2.1.1

a) Steering gear control system means the equipment by which orders are transmitted from the navigating room to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

b) Main steering gear means the machinery, rudder actuator(s), the steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.

c) Steering gear power unit means:

1. in the case of electric steering gear, an electric motor and its associated electrical equipment;
2. in the case of electrohydraulic steering gear, an electric motor and its associated electrical equipment and connected pumps;
3. in the case of other hydraulic steering gear, a driving engine and connected pump.

d) Auxiliary steering gear means the equipment other than any part of the main steering gear necessary to steer the ship in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

e) Power actuating system means the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components. i.e. tiller, quadrant and rudder stock, or components serving the same purpose.

f) Maximum ahead service speed means the greatest speed which the ship is designed to maintain in service at sea.

g) Rudder actuator means the component which converts directly hydraulic pressure into mechanical action to move the rudder.

h) Maximum working pressure means the expected pressure in the system when the steering gear is operated.

SECTION 3 Power piping arrangement

3.1 General

3.1.1 The power piping for hydraulic steering gears is to be arranged so that transfer between units can be readily effected.

3.1.2 Where the steering gear is arranged so that more than one system (either power or control) can be simultaneously operated, the risk of hydraulic locking caused by single failure is to be considered.

3.1.3 For all vessels with non-duplicated actuators, isolating valves are to be fitted at the connection of pipes to the actuator, and are to be directly fitted on the actuator.

3.1.4 Arrangements for bleeding air from the hydraulic system are to be provided where necessary.

3.1.5 Piping, joints, valves, flanges and other fittings are to comply with the Society's requirements for Class I components as prescribed in Part 5, Chapter 8, SECTION 13 of the “Rules and Regulations for the Classification and Construction of Steel Ships”. The design pressure is to be in accordance with 6.1.8.

SECTION 4 Rudder angle limiters

4.1 General

4.1.1 Power-operated steering gears are to be provided with positive arrangements, such as limit switches, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronized with the gear itself and not with the steering gear control.

SECTION 5 Materials

5.1 Strength requirements

5.1.1 Ram cylinders; pressure housings of rotary vane type actuators; hydraulic power piping valves flanges and fittings; and all steering gear components transmitting mechanical forces to the rudder stock (such as tillers, quadrants, or similar components) should be of steel or other approved ductile material, duly tested in accordance with the requirements of the Society. In general, such material should not have an elongation of less than 12% nor a tensile strength in excess of 650 N/mm^2. Grey cast iron may be accepted for redundant parts with low stress levels, excluding cylinders, upon special consideration.

SECTION 6 Design

6.1 General principles

6.1.1 The construction should be such as to minimize local concentrations of stress.

6.1.2 Welds

a) The welding details and welding procedures should be approved.
b) All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads should be full penetration type or of equivalent strength.

6.1.3 Oil Seals

a) Oil seals between non-moving parts, forming part of the external pressure boundary, should be of the metal upon metal type or of an equivalent type.
b) Oil seals between moving parts, forming part of the external pressure boundary, should be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage may be accepted at the discretion of the Administration.

6.1.4 All steering gear components transmitting mechanical forces to the rudder stock, which are not protected against overload by structural rudder stops or mechanical buffers, are to have a strength at least equivalent to that of the rudder stock in way of the tiller. Relevant calculations must be submitted for consideration.

6.1.5 For piping, joints, valves, flanges and other fittings see 3.1.5.

6.1.6 Rudder actuators are normally be designed in accordance with Class I pressure vessels (notwithstanding any exemptions for hydraulic cylinders).

6.1.7 In application of such rules the permissible primary general membrane stress is not to exceed the lower of the following values:

$$\frac{\sigma_B}{A} or \frac{\sigma_y}{B}$$

where:

σ_B= specified minimum tensile strength of material at ambient temperature, N/mm²,
σ_y= specified minimum yield stress or 2% proof stress of the material, at ambient temperature, N/mm²
A, B: given by the Table 6.1.1.

Table 6.1.1:

	Steel	**Cast Steel**	**Nodular Cast iron**
A	3.5	4	5
B	1.7	2	3

6.1.8 The design pressure is to be at least equal to the greater of the following:

a) 1,25 times the maximum working pressure.
b) the relief valve setting.

6.1.9 Accumulators, if any are to comply with Society requirements for pressure vessels.

6.2 Main steering gear

6.2.1 Main steering gear is to be at least capable of putting the rudder from 35 degrees on one side to 35 degrees on the other side with the vessel running ahead at maximum continuous shaft rpm and at the design waterline. For vessels with a required upper rudder stock diameter of 120 mm and greater, the main steering gear is to be power operated. The main steering gear is to be capable of putting the rudder over from 35 degrees on either side to 30 degrees on the other side in no more than 28 seconds. The arrangement of power operated steering gear fitted on vessels with a required upper rudder stock diameter of less than 120 mm will be specially considered.

6.3 Auxilliary steering gear

6.3.1 Effective auxilliary means for actuating the rudder is to be provided and when power operated is to be capable of putting the rudder from 15 degrees on one side to 15 degrees on the other side in not more than 60 seconds with the vessel running ahead at half speed, or 7 knots whichever is the greater. An auxilliary means of steering will not be required for the following arrangements:

a) When the steering gear comprises two or more power units, and two independent means of control are provided operable from the navigating room.
b) When non-power operated mechanical main steering gear is used.
c) When steering is accomplished by positioning the propulsion unit.

6.4 Protection

6.4.1 The main steering gear is to be protected from the weather and the auxilliary steering gear is to be so protected as to permit satisfactory operation in bad weather.

SECTION 7 Dynamic loads for fatigue and fracture mechanic analysis

7.1 Specification

7.1.1 The assumed dynamic loading in the fatigue and fracture mechanics analysis is to be submitted for consideration. Both the case of high cycle and cumulative fatigue are to be considered.

SECTION 8 Hoses

8.1 Requirements

8.1.1 Hose assemblies of type approved by the Society may be installed between two points where flexibility is required but should not be subjected to torsional deflection (twisting) under normal operating conditions. In general, the hose should be limited to the length necessary to provide for flexibility and for proper operation of machinery.

8.1.2 Hoses should be high pressure hydraulic hoses according to recognized standards and suitable for the fluids, pressures, temperatures and ambient conditions in question.

8.1.3 Rupture pressure of the hoses should not be less than four times the design pressure.

SECTION 9 Relief valves

9.1 Requirements

9.1.1 Relief valves for protecting any part of the hydraulic system which can be isolated, as required by SOLAS Regulation 29.2.3 should comply with the following:

a) The setting pressure should not be less than 1,25 times the maximum working pressure.
b) The minimum discharge capacity of the relief valve(s) should not be less than the total capacity of the pumps, which can deliver through it (them), increased by 10%.

Under such conditions the rise in pressure should not exceed 10% of the setting pressure. In this regard, due consideration should be given to extreme foreseen ambient conditions in respect of oil viscosity. The Society may require, for the relief valves, discharge capacity tests and/or shock tests.

SECTION 10 Electrical installations

10.1 Requirements

10.1.1 Electrical installations should comply with the requirements of Part 6 of these Rules.

SECTION 11 Alternative source of power

11.1 General

11.1.1 Where the rudder stock is required to be over 230 mm diameter in way of the tiller an alternative power supply, sufficient at least to supply the steering gear power unit which complies with the requirements of 6.3 and also its associated control system and the rudder angle indicator , shall be provided automatically, within 45 seconds, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power should be used only for this purpose.

11.1.2 Where the required alternative power source is a generator, or an engine driven pump, automatic starting arrangements are to comply with the requirements relating to the automatic starting arrangements of emergency generators.

SECTION 12 Monitoring and alarm systems

12.1 Requirements

12.1.1 Monitoring and alarm systems, including the rudder angle indicators, should be designed, built and tested to the satisfaction of the Society (see also Part 8, Chapter 1).

12.1.2 Where hydraulic locking, caused by a single failure, may lead to loss of steering, an audible and visual alarm, which identifies the failed system, shall be provided on the navigating bridge.

SECTION 13 Operating instructions

13.1 General

13.1.1 Appropriate operating instructions with a block diagram showing the change-over procedures for the steering gear control systems and steering gear actuating systems should be permanently displayed in the wheel-house and in the steering gear compartment. Where the system failure alarms according to SECTION 12 are provided, appropriate instructions shall be placed on the navigating bridge to shut down the failed system.

SECTION 14 Testing and trials

14.1 Testing

14.1.1 The requirements of the Society relating to the testing of Class I pressure vessels, piping, and relating fittings including hydraulic tenting apply.

14.1.2 A power unit pump is to be subjected to a type test. The type test shall be for a duration of not less than 100 hours, the test arrangements are to be such that the pump may run in idling conditions, and at maximum delivery capacity at maximum working pressure. During the test, idling periods are to be alternated with periods at maximum delivery capacity at maximum working pressure. The passage from one condition to another should occur at least as quickly as on board. During the whole test no abnormal heating, excessive vibration or other irregularities are permitted. After the test, the pump should be disassembled and inspected. Type tests may be waived for a power unit which has been proven to be reliable in marine service.

14.1.3 All components transmitting mechanical forces to the rudder stock should be tested according to the requirements of the Society.

14.1.4 After installation on board the vessel the steering gear is to be subjected to the required hydrostatic and running tests.

14.2 Trials

14.2.1 The steering gear should be tried out on the trial trip in order to demonstrate to the Surveyor's satisfaction that the requirements of the Rules have been met. The trial should include the operation of the following, as applicable:

a) the steering gear, including a demonstration of the performances required in 6.2 and 6.3, with craft running ahead at maximum continuous rpm;
b) auxilliary steering gear performance and transfer between main and auxilliary steering gear;
c) the power units including transfer between power units;
d) the steering gear controls, including transfer of control and local control;
e) the alarms and indicators; these tests may be effected at dockside;
f) where steering gear is designed to avoid hydraulic locking this feature shall be demonstrated;
g) the rudder angle indicator;
h) the motor indicators.

Rules and Regulations

for the

Classification and Construction of

SMALL CRAFTS

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Part 6 - Electrical Installations

June 2019

CHAPTER 1 GENERAL REQUIREMENTS

SECTION 1 General

1.1 Scope

1.1.1 The requirements of this part apply to electrical installations where the aggregate generator capacity does not exceed 75 kW. Otherwise the requirements of Part 6 of the Society's "Rules and Regulations for the Classification and Construction of Steel Ships".

1.1.2 Electrical installations in machinery spaces with gasoline engines will be specially considered.

SECTION 2 Documentation

2.1 Documents for approval

2.1.1 The following drawings and data, as applicable, are to be submitted for approval before the commencement of work:

a) electrical one line diagram,
b) electrical switchboards and panelboards,
c) electrical power and lighting systems,
d) emergency electrical systems,
e) internal communication system,
f) alarm systems,
g) navigating lights,
h) propulsion control system,
i) steering gear power and control systems,
j) impressed current cathodic protection system,
k) electrical load analysis.

SECTION 3 Installation

3.1 Equipment location

3.1.1 Electrical equipment is to be suitably placed and protected as to minimize the probability of mechanical injury or damage due to the accumulation of dust, oil vapours, steam or dripping liquids.

3.1.2 Apparatus liable to arc is to be ventilated or placed in ventilated compartments in which flammable gases, acid fumes and oil vapours cannot accumulate. Skylights and ventilators are to be so arranged as to avoid the probability of flooding the apparatus.

3.2 Protection from bilge water

3.2.1 All generators and motors are to be so arranged that they cannot be damaged by bilge water.

3.2.2 A watertight coaming is to be provided to form as well around the base of such equipment with provision for removing water from the wall, if it is considered necessary.

3.3 Accessibility

3.3.1 The design and arrangement of electrical apparatus is to provide accessibility to parts requiring inspection or adjustment.

3.4 Watertight equipment

3.4.1 All electrical equipment exposed to the weather or located in spaces where it would be exposed to seas, splashing or other severe moisture conditions is to be of the watertight type or be protected by means of watertight enclosures.

3.5 Corrosion resistant parts

3.5.1 Any parts of electrical equipment which would be damaged or rendered ineffective by corrosion are to be made of corrosion resistant materials.

3.6 Grounding of permanent equipment

3.6.1 Frames or cases of all permanently installed generators, motors, controllers, switchboards, panelboards, instruments and similar equipment, for which the arrangement and method of installation does not assure positive grounding are, normally, to be permanently grounded through separate conductors protected against damage.

3.6.2 Where outlets, switches and similar fittings are of non-metallic construction, grounding of all exposed metal parts is to be insured.

3.7 Lightning protection

3.7.1 lightning-protection system consisting of a copper spike, and a copper conductor of cross sectional area at least 8 mm^2 is to be installed on each non-metallic mast. The spike is to project at least 150 mm above the uppermost part of the vessel, the conductor is to run clear of metal objects and as straight as practicable to the metallic steel structure of the vessel.

SECTION 4 Bridge control of propulsion machinery

4.1 General

4.1.1 The following are applicable for vessels with length L over 20 m.

4.2 Control capability

4.2.1 Under all sailing conditions, including manoeuvring, the speed, direction of thrust and, if applicable, the pitch of the propeller are to be fully controllable from the navigating bridge.

4.2.2 This control is to be performed by a single control device for each independent propeller, with automatic performance of all associated services, including, where necessary, means of preventing overload of the propulsion machinery.

4.3 Emergency stopping

4.3.1 The propulsion machinery is to be provided with an emergency stopping device on the navigating bridge which is independent from the bridge control system.

4.4 Order of control station command

4.4.1 Where multiple control stations are fitted, remote control of the propulsion machinery is to be possible only from one station at a time; at one control station interconnected control units are permitted. There is to be at each station an indicator showing which station is in control of the propulsion machinery.

4.4.2 The transfer of control between navigation bridge and machinery spaces is to be possible only in the machinery space.

4.5 Local control

4.5.1 It is to be possible to control essential machinery and the propelling machinery locally in the case of failure in any part of the automatic or remote control systems.

4.6 Bridge control indicators

4.6.1 Indicators for the following are to be fitted on the navigating bridge:

a) Propeller speed and direction where fixed pitch propellers are fitted.
b) Propeller speed and pitch position where controllable pitch propeller are fitted.
c) An alarm is to be provided to indicate low starting air pressure and is to be set at a level which still permits main engine starting operation.

SECTION 5 Trials

5.1 Ship's Service

5.1.1 All auxiliary apparatus is to be tried under working conditions.

5.1.2 Each generator is to be run for a time sufficient to show satisfactory operations. When two or more generators arranged for parallel operation are installed, parallel operation with all possible combinations is to be demonstrated.

5.1.3 Each auxiliary motor necessary to the operation of the vessel is to be run for a time sufficient to show satisfactory performance. All main switches and circuit breakers are to be operated but not necessarily at full load. The operation of the lighting system, heaters, etc., is to be demonstrated satisfactorily. The entire installation is to operate to the satisfaction of the Surveyors.

CHAPTER 2 INSTALLATIONS OF REDUCED CAPACITY

SECTION 1 General

1.1 Application

1.1.1 The requirements of this chapter are to be applied to electrical installations where the aggregate generator capacity does not exceed 75 kW.

1.2 Ambient temperature

1.2.1 In the requirements of this Chapter an ambiant temperature of 40°C has been assumed for all locations. Where the ambient temperature is in excess of this value, the total temperature specified is not to be exceeded. Where equipment has been rated on ambient temperature less than that contemplated, consideration will be given to the use of such equipment provided the total temperature for which the equipment is rated will not be exceeded.

SECTION 2 Generators

2.1 Capacity

2.1.1 Vessels using electricity for propulsion auxiliaries (e.g., independent fuel pumps, oil pumps) and the safety of the vessel, are to be provided with at least two generators. These generators are not to be driven by the same engine.

2.1.2 The capacity of the generator set or sets is to be sufficient to carry the necessary load essential for the propulsion and safety of the vessel, and minimum comfortable conditions of habitability with any one generator set in reserve.

2.1.3 Vessels having only one generator are to be provided with a battery source to supply sufficient lighting for safety.

2.2 Protection

2.2.1 Generators of less than 25 KW not arranged for parallel operation may be protected by fuses.

2.2.2 All generators of 25 KW and over are to be protected by a trip-free air circuit breaker providing longtime over-current protection not exceeding 15% above either the full-load rating of continuous-rated machines, or the overload rating of special-rated machines. The shutting down of the prime mover is to cause the tripping of the ship service generator circuit breaker.

SECTION 3 Storage batteries

3.1 Location

3.1.1 Storage batteries are to be located in well-ventilated areas as high above the bilges as possible and as far away as practicable from potential sources of ignition.

3.2 Installation

3.2.1 Lead-acid storage batteries are to be installed in liquid-tight trays lined with lead or other suitable materials.

3.2.2 Alkaline storage batteries are to be installed on suitable insulating supports, and when metal cell containers are used these are to be protected against conducting materials that can cause short-circuiting between the containers and metal structure.

3.2.3 Batteries are to have not less than 250 mm vertical clearance and are to be chocked all around to prevent their movement due to the motion of the vessel.

3.3 Charging

3.3.1 Means are to be provided for determining the charged condition of storage batteries and for charging them when necessary.

3.3.2 Where voltage-dropping resistors are utilized, they are to be mounted in a well-ventilated non-combustible enclosure situated away from other combustible material.

3.3.3 Battery-charging circuits are to have over-current and reverse-current protection. In addition a disconnect switch should be provided before the battery charger.

3.4 Connections

3.4.1 Connections to storage batteries are to be made with fitted connectors providing good mechanical and electrical unions. Spring clips or other temporary clamps are not to be used.

SECTION 4 Cables

4.1 Construction

4.1.1 Cables are to have copper conductors constructed and sized in accordance with a recognized standard and are to be of the stranded type, except sizes not exceeding 1,5 mm² may have solid conductors.

4.2 Installation

4.2.1 All wiring is to be placed as high as possible above the bilges, and cable runs are to be made without splices and be as straight and accessible as practicable.

4.2.2 Cables installed in machinery spaces are to have an insulation with a temperature rating of not less than 75°C. They are to be effectively supported and secured, and protected against mechanical damage.

4.2.3 Cables exposed to moisture are to be moisture-resisting jacketed. All cable entrances in exposed locations and all penetrations through watertight decks and bulkheads are to be made watertight.

SECTION 5 Distribution boxes and panels

5.1 Construction

5.1.1 Distribution boxes and panels are to be of non-combustible material and are to be preferably of the dead-front type. They may be of metal or of non-conductive material. If of metal, they are to be grounded in accordance with the requirements of Part 6, Chapter 1, SECTION 3, 3.6.

5.1.2 All terminal strips, fuse blocks, switches, and similar equipment are to be of non-combustible high-dielectric-strength insulating material.

5.2 Installation

5.2.1 Distribution boxes and panels are to be installed in dry accessible, and well-ventilated spaces.

5.2.2 Adequate clearance, not less than 610 mm, is to be provided in front of distribution boxes and panels. When located at the helm or other area adjacent to or part of an open cockpit or weather deck, they are to be protected by a watertight enclosure.

5.3 Instrumentation

5.3.1 For each installed generator the following instruments are to be provided:

a) voltmeter,
b) amperometer,
c) frequency meter, and
d) voltage regulator.

5.3.2 Control equipment and measuring instruments are to be provided as necessary to insure satisfactory operation of the generator or generators.

5.3.3 If the electrical installation is designed for single generator or non-parallel operation, the requirement for a frequency meter is not required.

5.3.4 In case of generators which may be operated in parallel, a synchroscope with lamp, prime mover control, and wattmeter is also to be provided.

SECTION 6 Protective devices

6.1 General

6.1.1 All conductors are to be protected in accordance with 6.2. Feeder and branch circuits for lighting, heating or ship’s service power are to have each ungrounded conductor protected by a circuit breaker or fuse of suitable interrupting capacity.

6.1.2 Circuit breakers are to be of the independent-arm or trip-free type. Circuit breakers may be equipped with time trips, instantaneous trips or trips consisting of both time over-current and instantaneous features.

6.2 Over-current protection devices

6.2.1 Fuse rating and ratings (or settings, if adjustable) of time-delay trip elements of circuit breakers are not to exceed the rated current capacity of the conductor to be protected except as otherwise permitted for motor branch-circuit protection. If the standard ratings and settings of over-current devices do not correspond with the rating and setting allowed for conductors, the next higher standard rating setting may be used, but not exceeding 150% of the allowable current carrying capacity of the conductor. Except as otherwise permitted for motor branch-circuit protection, adjustable-trip circuit breakers of the time-delay or instantaneous type are to be set to operate at not more than 150% of the rated capacity of the conductor to be protected.

6.2.2 The rating or appropriate setting of the overload protective device for each circuit is to be permanently indicated at the location of the protective device.

6.2.3 Branch lighting circuits are to be protected by over-current protective devices rated or set at not more than 30 amperes. The connected load is not to exceed the rated current carrying capacity of the conductor or 80% of the over-current protective device rating or setting. Where the over-current protective device rating or setting exceeds 20 amperes, lighting fixtures are to be of the heavy-duty type and switches are to be rated for the load controlled.

6.2.4 Isolated heaters or groups of heaters may be supplied by branch lighting circuits.

6.2.5 Running protection is to be provided for all motors except such protection is not to be provided for steering gear motors. The running protection is to be set between 100% and 125% of the motor rated current.

SECTION 7 Emergency source of power

7.1 General

7.1.1 All vessels having only one generator are to be provided with a source of emergency electrical power sufficient to supply emergency lighting for at least 6 hours. The power source may be any one of the following:

a) An automatically connected or manually controlled standard battery; or
b) An automatically or manually started generator; or
c) Relay-controlled, battery-operated lanterns.

SECTION 8 Navigating running lights

8.1 General

8.1.1 Mast head, port, starboard, and stern lights when required are to be controlled by a running light indicator panel. A fused-feeder disconnect switch is to be provided; the rating of the fuses is to be at least twice that of the largest branch fuse and greater than the maximum panel load.

SECTION 9 Distribution cables

9.1 General

9.1.1 All electric cables for power, lighting, communication, control and electronic circuits are to have insulations suitable for a conductor temperature of not less than 75°C. The rated operating temperature for the insulating material is to be at least 10°C higher than the maximum ambient temperature likely to exist, or to be produced, in the space where the cable is installed.

9.1.2 Electric cables are not to enter oil tanks.

9.1.3 Cables are to be installed in such a manner that stresses on the cable are not transmitted to the conductors.

9.1.4 Joints in wires and cables are to be made in flame-retarding wire appliances. Special consideration may be given to methods of splicing that retain the original mechanical and electrical properties of the cable.

9.1.5 Terminal boxes are to be secured in place and the moisture-resistant jacket is to extend through the cable clamp.

9.1.6 Enclosures for outlets, switches, and similar fittings are to be flame and moisture-resistant, and of adequate mechanical strength and rigidity to protect the contents and to prevent distortion under all likely conditions of service.

9.2 Cables behind paneling and in dome fixtures

9.2.1 Cables may be installed behind paneling, provided all connections are accessible and the location of concealed connection boxes is indicated.

9.2.2 Dome fixtures are to be installed so that they are vented, or they are to be fitted with fire-resistant material in such a manner as to protect the insulated wiring leading to the lamps and any exposed woodwork from excessive temperature.

9.3 Cables behind sheathing

9.3.1 Cables may be installed behind sheathing, but they are not to be installed behind or imbedded in structural insulation; they are to pass through such insulation at right angles and are to be protected by a continuous pipe with a stuffing tube at one end. For deck penetrations this stuffing tube is to be at the upper end of the pipe and for bulkhead penetrations it is to be on the uninsulated side of the bulkhead.

9.3.2 Cable supports and bends

Cables are to be adequately supported. Supports for cables are to be spaced not more than 0,61 m apart in both horizontal and vertical directions. Cables grouped in a single support are to be limited to two banks except for turnouts. Cables running transversely to the underside of beams are to be supported in cable racks or the equivalent. Cables are not to be bent to a smaller radius than 6 diameters (8 diameters for armored cable).

9.3.3 Deck and bulkhead penetrations.

Where cables pass through watertight, firetight, or smoke-tight bulkheads or decks, the penetrations are to be made through the use of approved stuffing tubes, transit devices, or pourable materials which will maintain the watertight, firetight or smoke-tight integrity of the bulkheads or decks. Additionally, each stuffing tube, transit device, or pourable material is not to damage the cable physically or through chemical action or heat build-up. When cables pass through nonwatertight bulkheads where the bearing surface is less than 6,4 mm, the holes are to be fitted with bushings having rounded edges and a bearing surface of at least 6,4 mm, in length. Where cables pass through deck beams, or similar structural parts, all burrs are to be removed in way of the holes and care is to be taken to eliminate any sharp edges.

9.3.4 Grounding of cable metallic covering

Each armored cable and each mineral-insulated metal-sheathed cable is to have the metallic covering electrically and mechanically continuous and grounded to the metal hull of each end of the run except that final subcircuits may be grounded at the supply and only.

9.3.5 Mechanical properties

All cables liable to damage, such as in locations in way of hatches, open decks subject to seas, and where passing through decks, are to be protected by substantial metal shields, structural shapes, pipe or other equivalent means. All such coverings are to be of sufficient strength to provide effective protection to the cables, and if metallic, are to be electrically continuous and grounded to the metal hull. Horizontal pipes or the equivalent used for cable protection are to be provided with drainage holes and where they are carried through decks or bulkheads, arrangements are to be made to insure the integrity of the water or gas tightness of the structure.

SECTION 10 Splicing of electrical cables

10.1 Location

10.1.1 Electric cables are to be installed in continuous lengths between terminations; however, approved splices will be permitted when necessary to extend existing circuits for a vessel undergoing repair or alteration. Splicing procedure and location of splices are to be submitted for approval.

10.2 Installation

10.2.1 All splices are to be made after the cable is in place and are to be accessible for inspection. The conductor splice is to be made using a pressure type butt connector by use of a one-cycle compression tool.

SECTION 11 Permanent watertight fixtures

11.1 General

11.1.1 Permanent watertight fixtures are to be corrosion-resistant and are to be used where exposed to the weather or splashing water. Lighting fixtures of this type are to be rendered watertight by means of glass globes protected by substantial guards. Watertight lighting fixtures are not required for any interior locations except for refrigerated compartments or where exposed to splashing water.

CHAPTER 3 FRP HULL VESSELS

SECTION 1 General requirements

1.1 General

1.1.1 In case of FRP hull vessels the additional requirements of this chapter should be taken into account.

1.2 Equipment grounding

1.2.1 All electrical encolsures, fittings and similar equipment are to be permanently grounded to the generator frame and engine bedplate with equipment grounding conductors that are at least as large as the conductors supplying the equipment.

1.2.2 All generator frames are to be connected with equipment grounding conductors at least as large as the generator conductors.

1.2.3 On systems using grounded neutrals, the neutral is not to be used as an equipment ground.

1.3 Lighting protection

1.3.1 A lighting-protection system consisting of a copper spike, a copper conductor of at least 8 and a grounding plate of not less than 450 cm² is to be installed.

1.3.2 The spike is to project at least 150 mm above the uppermost part of the vessel. The conductor is to run clear of metal objects and as straight as practicable.

1.3.3 The grounding plate is to be located so that it is immersed under all conditions of heel. Metallic rudders may be used as grounding plates.

CHAPTER 4 ALUMINIUM HULL VESSELS

SECTION 1 General requirements

1.1 General

1.1.1 In case of aluminium hull vessels, the additional requirements of this Chapter should be taken into account.

1.1.2 In general, electrical systems are to be isolated from the hull at all times or a suitable cathodic protection arrangement is to be provided. Floating ground systems between the engine and related machinery components may be installed where it is required. In addition to power supply systems, attention for maintaining electrical isolation is to be given to communication devices, instrumentation and shore-power systems where used.

1.2 DC systems

1.2.1 Batteries generally are not to be grounded to propulsion engines or related machinery components.

1.2.2 Where it is necessary for batteries to be grounded to the hull, the negative plies are to be connected to the hull.

1.2.3 Batteries for engine starting may be grounded to the engine.

1.3 AC systems

1.3.1 AC power supplies are to be isolated from the hull at all times. A high resistance continuity tester is to be carried on board in order that the electrical installation may be checked at the time of installation and at regular intervals to insure correct isolation of AC circuits.

1.4 Shore power

1.4.1 The shore electrical power is to enter the vessel through a 1:1 isolation transformer. Additional precautions to prevent electrolysis of the hull when docking are recommended.

1.5 Impressed current systems

1.5.1 Where impressed current cathodic protection systems are proposed, complete details, including types of anodes, voltages, arrangements and schematic of the wiring system, are to be submitted for review.

1.5.2 Cables for cathodic protection systems are not to be run through oil tanks. Where passing through cofferdams, pump-room and similar hazardous spaces, cables are to be encased in extra-heavy pipe, and are to be shielded from damage in cargo spaces and other areas where they may be exposed to mechanical damage.

1.5.3 If piping used is not aluminium, it is to be isolated from the hull.

1.5.4 Impressed current cathodic protection systems are to be equipped with alarm devices to indicate inadequate or excessive current and reversed polarity.

Rules and Regulations

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PHOENIX REGISTER OF SHIPPING

Part 1 – Classification

Part 2 - Materials

Part 3 - Hull Construction and Equipment

Part 4 - Specialized Vessels

Part 5 - Machinery

Part 6 - Electrical Installations

Part 7 - Fire Protection, Detection and Extinction

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PHOENIX REGISTER OF SHIPPING

Part 7 - Fire Protection, Detection and Extinction

June 2019

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SECTION 1 - General

1.1 Application

1.1.1. Cargo ships of 500 gross tons or more, all passenger ships and gas and chemical tankers on international voyages, where provision is made within International Conventions, are to be provided with the fire safety measures required by the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS 74). Fishing vessels of 24 m freeboard length and over are to be provided with the fire safety measures required by the Torremolinos Protocol of 1993 relating to the Torremolinos International Convention for the Safety of Fishing Vessels, 1977 (Torremolinos Protocol).

1.1.2. Cargo ships of 500 gross tons or more, all passenger ships, and gas and chemical tankers, employed on national voyages are to comply with the fire safety measures prescribed and approved by the Government of the flag state.

1.1.3. It is the responsibility of the Government of the flag state to give effect to the fire protection, detection and extinction requirements of 1.1.1 and 1.1.2. However the Society will undertake to do this in cases where contracting Governments have authorized PHRS to apply the requirements of SOLAS 74 or the Torremolinos Protocol and issue the appropriate certification on their behalf.

1.1.4 The requirements of Chapter 2 of this Part, are applicable to cargo ships of less than 500 gross tons, (where not covered by International Conventions), fishing vessels of 12 m registered length and over but less than 45 m freeboard length, and ships not fitted with propelling machinery.

1.1.5. Consideration will be given to the acceptance of fire safety measures prescribed and approved by the Government of the flag state in lieu of 1.1.4.

1.1.6. Special consideration, consistent with the fire hazard involved, will be given to construction or arrangement features not covered by this Chapter.

1.1.7. Cargo ships of less than 500 gross tons intended for the carriage of dangerous goods are to comply with SOLAS 1974 as amended II-2/G, 19.

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SECTION 2 - Fire protection, detection and extinction

2.1 General provisions

2.1.1 The provisions of these requirements are intended to apply to new and, as far as reasonable and practicable, or as found necessary by the relevant Administration, to existing cargo ships of less than 500 GT.

2.1.2 It should be remembered that the International Codes for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk and Liquefied Gases in Bulk are applicable to such ships regardless of size including those of less than 500 GT.

2.1.3 In lieu of the requirements of the present Chapter, consideration will be given to the acceptance of fire safety measures prescribed and approved by the Government of the flag state.

2.2 Surveys and maintenance

2.2.1 The hull, machinery and all equipment required for safety aspects of every ship should be constructed and installed so as to be capable of being regularly maintained to ensure that they are at all times, in all respects, satisfactory for the ship's intended service.

2.2.2 A competent authority should arrange for appropriate surveys of the required equipment relating to fire safety aspects during construction and, at regular intervals after completion, generally as prescribed within Chapter I of SOLAS 1974 (as amended). Such surveys should be carried out by the Society classing the ship or the Flag State.

2.2.3 The condition of the structural fire protection and fire safety related equipment shall be maintained to conform with the provisions of the requirements to ensure that the ship in these respects, will remain fit to proceed to sea without danger to the ship or persons on board. The hull structure and machinery do not form part of these requirements but should be similarly surveyed and maintained.

2.3 Requirements

2.3.1. Table 2.1. (1) details the various minimum fire protection, detection and extinction arrangements that are required depending on the vessel's intended service area.

Table 2.1.(1) General fire detection, protection and extinction requirements

Fire-fighting equipment	**Unrestricted Service**	**Restricted Service** (**RIS** and **CS** notations)	**Sheltered water service** (**SW** and **ESW** notations)
1. FIRE PUMPS			
Ships greater than 150 GT			
- Independently driven power pumps	1	1	1
- Power pumps	1	1	—
- Hand pumps	—	—	1
Ships less than 150 GT			
- Independently driven power pumps	—	—	—
- Power pumps	1	1	1
- Hand pumps	1	1	—
2. FIRE HYDRANTS Sufficient number and so located that at least one powerful water jet can reach any normally accessible part of ship	X	X	X
3. FIRE HOSES (Length >15 m) With couplings and nozzles	>=3	>=3	>=2
4. FIRE NOZZLES Dual purpose (spray/jet) with 12 mm jet and integral shut-off. Jet may be reduced to 10mm and shut-off omitted for hand pump hoses.	X	X	X
5. PORTABLE FIRE EXTINGUISHERS			
- Accommodation and service spaces.	>3	>=3	>=2
- Boiler rooms, etc.	>2	>=2	>=2
- Machinery spaces (one extinguisher per 375 kw of internal combustion engine power)	>=2,<=6	>=2,<=6	>=2,<=6
- Cargo pump rooms (capacity 9 l. fluid or equivalent)	>2	>2	>=2
6. NON-PORTABLE FIRE EXTINGUISHERS IN MACHINERY SPACES			
- Ships greater than 150 GT	1	1	-
- Ships greater than 350 GT (capacity 45l fluid or equivalent)	-	-	1
7 . FIXED FIRE EXTINGUISHING SYSTEMS SHIPS GREATER THAN 350 GT			
Category A machinery spaces	X	X	-
Cargo pump rooms	X	X	-
8. CARGO TANK PROTECTION Mobile foam appliances	X	X	X

9. FIREMAN'S OUTFIT **Ships greater than 150 GT** - complete outfit **Ships less than 150 GT** - complete outfit Fireman's axe	 >=2 >=1 -	 >=2 >=1 -	 >=2 - 1
10. MEANS OF ESCAPE Accommodation and service spaces Machinery spaces Cargo pump rooms	 2 >=1 1	 2 >=1 1	 2 >=1 1
11. STRUCTURAL FIRE PROTECTION WHEEL HOUSE AND MACHINERY SPACES Separation from adjacent spaces of negligible fire risk Separation from other adjacent spaces Escape routes	 A-0 A-60 B-0	 A-0 A-60 B-0	 A-0 A-60 B-0

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Part 8 – Control Engineering Systems

June 2019

CHAPTER 1 GENERAL

SECTION 1 General requirements

1.1 General

1.1.1 The requirements of this Chapter are applicable to small craft over 24 m where it is intended to assign the “UMS” notation for operation with the machinery space unattended.

1.1.2 The control engineering installations for small craft over 24 m are to be arranged and installed as far as it is practicable in accordance with the relevant Sections of Part 8, Chapter 1 of the Rules and Regulations for the Classification and Construction of Steel Ships.

1.1.3 The Committee is prepared to give consideration to alternative arrangements.

1.1.4 In any case additional requirements of the national Authority of the country in which the ship is to be registered and to the relevant regulations of SOLAS, Torremolinos, International Convention for the safety of fishing vessels, or International Code of safety for High-Speed Craft (H.S.C.) have to be satisfied with as applicable.

1.2 Plans

1.2.1 Plans required by 1.2.2, 1.2.3, 1.2.4 and 1.2.5 are to be submitted in triplicate.

1.2.2 Where control, alarm and safety systems are intended for the machinery or equipment as listed in 1.2.3 the following is to be submitted:

a) Description of operation with explanatory diagrams
b) Line diagrams of control circuits
c) List of alarm points
d) Test schedules which should include methods of testing and test facilities provided.

1.2.3 Plans for the control, alarm and safety systems of the following are to be submitted where applicable:

a) Air compressors.
b) Controllable pitch propeller.
c) Electric generating plant.
d) Fire detection systems.
e) Main propelling machinery including essential auxiliaries.
f) Oil fuel transfer and storage systems.
g) Steam raising plant (boilers and their ancillary equipment)

1.2.4 Alarm systems. Details of the overall alarm system linking control stations, the bridge area and accommodation are to be submitted.

1.2.5 Control station. Location and details of control stations are to be submitted, e.g. control panels and consoles.

1.3 Alterations or additions

1.3.1 When an alteration or addition to the approved systems is provided, plans are to be submitted for approval. The alterations or additions are to be carried out under survey and the inspection, testing and installation are to be to the Surveyor’s satisfaction.

SECTION 2 Essential safety features

2.1 General

2.1.1 Where it is proposed to operate the small craft above 24 m with the machinery space unattended no matter what period is envisaged, the safety features specified in 2.2, 2.3, 2.4, 2.5, 2.6, 2.7 and 2.8 are to be installed. For guidance, the relevant requirements of Part 8, Chapter 1 of the Rules and Regulations for the Classification and Construction of Steel Ships should be considered in respect of control, alarm and safety system design and the extent of the installation.

2.2 Alarm system

2.2.1 An alarm system is to be installed which will warn the engineering staff, or the bridge personnel or both of fault conditions which are a potential hazard to the machinery or the craft.

2.3 Bridge control

2.3.1 Means are to be provided to ensure satisfactory control of the propulsion machinery from the bridge. Sufficient instrumentation is to be provided on the bridge to indicate that the bridge command has been carried out.

2.4 Fire detection

2.4.1 An automatic fire detection and alarm system is to be fitted in the machinery space.

2.5 Fire prevention

2.5.1 Means are to be provided to prevent leaks from high pressure oil fuel injection piping for main and auxiliary engines dripping or spraying onto hot surfaces or into machinery air inlets. Such leakage, where practical, should be lead to collector tank(s) fitted in a safe position with an alarm to indicate that leakage is taken place.

2.6 Bilge level alarm

2.6.1 Means are to be provided to warn that water in the machinery space bilges has reached a predetermined high level.

2.7 Control station for machinery

2.7.1 A station is to be provided which indicates alarms for fault conditions in the machinery and which allows easy access to controls for starting, stopping and generally controlling essential machinery.

2.8 Local manual controls

2.8.1 It shall be possible to operate the essential machinery with control systems out of action

SECTION 3 Testing

3.1 Trials

3.1.1 Before a new installation, or any alternation or addition to an existing installation, is put into service, trials are to be carried out. These trials are in addition to any acceptance tests which may have been carried out at the manufacturers' works and are to be based on the approved test schedules as required by 1.2.2.