



**BUREAU  
VERITAS**

# **RULES for the CLASSIFICATION of CREW BOATS**

**MAY 2005**

**Rule Note  
NR 490 DTM R01 E**

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**BUREAU  
VERITAS**

## MARINE DIVISION GENERAL CONDITIONS

### ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine Division (the "Society") is the classification ("Classification") of any ship or vessel or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

- prepares and publishes Rules for classification, Guidance Notes and other documents ("Rules");
- issues Certificates, Attestations and Reports following its interventions ("Certificates");
- publishes Registers.

1.2. - The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as "Certification".

1.3. - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

1.4. - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as "Services". The party and/or its representative requesting the services is hereinafter referred to as the "Client". **The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.**

1.5. - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Shipbuilder, Repair yard, Charterer or Shipowner who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

### ARTICLE 2

2.1. - Classification is the appraisalment given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisalment is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

2.2. - Certification is carried out by the Society along the same lines as set out in Articles 3 and 4 hereafter and with reference to the applicable National and International Regulations or Standards.

2.3. - **It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraisalment or cause to modify its scope.**

2.4. - The Client is to give to the Society all access and information necessary for the performance of the requested Services.

### ARTICLE 3

3.1. - **The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are not a code of construction neither a guide for maintenance or a safety handbook.**

Committees consisting of personalities from the Industry contribute to the development of those documents.

3.2. - **The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.**

3.3. - The Services of the Society are carried out by professional Surveyors according to the Code of Ethics of the Members of the International Association of Classification Societies (IACS).

3.4. - **The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.**

### ARTICLE 4

4.1. - The Society, acting by reference to its Rules:

- reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- conducts surveys at the place of their construction;
- classes Units and enters their class in its Register;
- surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

**The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.**

### ARTICLE 5

5.1. - **The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.**

5.2. - **The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for.**

In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

5.3. - **The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder, respectively.**

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

### ARTICLE 6

6.1. - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

6.2. - **If the Services of the Society cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee.**

**The Society bears no liability for indirect or consequential loss such as e.g. loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.**

6.3. - All claims are to be presented to the Society in writing within three months of the date when the Services were supplied or (if later) the date when the events which are relied on were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred.

### ARTICLE 7

7.1. - Requests for Services are to be in writing.

7.2. - **Either the Client or the Society can terminate as of right the requested Services after giving the other party thirty days' written notice, for convenience, and without prejudice to the provisions in Article 8 hereunder.**

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. hereabove subject to compliance with 2.3. hereabove and Article 8 hereunder.

### ARTICLE 8

8.1. - The Services of the Society, whether completed or not, involve the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

8.2. - **Overdue amounts are increased as of right by interest in accordance with the applicable legislation.**

8.3. - **The class of a Unit may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.**

### ARTICLE 9

9.1. - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

- Clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the **classification file** consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit ;
- copy of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society Member of the International Association of Classification Societies (IACS) in case of the Unit's transfer of class;
- the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units are passed on to IACS according to the association working rules;
- the certificates, documents and information relative to the Units classed with the Society may be reviewed during IACS audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

### ARTICLE 10

10.1. - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

### ARTICLE 11

11.1. - In case of diverging opinions during surveys between the Client and the Society's surveyor, the Society may designate another of its surveyors at the request of the Client.

11.2. - Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Marine Advisory Committee.

### ARTICLE 12

12.1. - Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

12.2. - Disputes arising out of the payment of the Society's invoices by the Client are submitted to the Court of Nanterre, France.

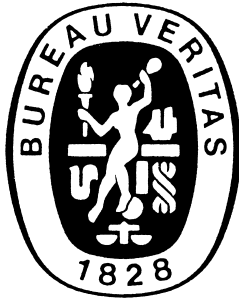
12.3. - **Other disputes over the present General Conditions or over the Services of the Society are exclusively submitted to arbitration, by three arbitrators, in London according to the Arbitration Act 1996 or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by English law.**

### ARTICLE 13

13.1. - **These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement.**

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

13.3. - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.



RULE NOTE NR 490

# RULES FOR THE CLASSIFICATION OF CREW BOATS

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**Unless otherwise specified, these rules apply to ships for which contracts are signed after July 1st, 2005. The Society may refer to the contents hereof before July 1st, 2005, as and when deemed necessary or appropriate.**

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# SECTION 1

# GENERAL

## 1 General

### 1.1 Application

**1.1.1** Requirements of these Rules are applicable to crew boats as defined in [2.1.1] of less than 500 GRT and length not greater than 45m, with hull made of steel or aluminium, and proceeding in the course of their voyage not more than four hours at operational speed from a place of refuge.

The present Rules are normally applicable to crew boats having a maximum service speed  $V$ , in knots, greater or equal to  $7,16 \Delta^{1/6}$ , where  $\Delta$  is the moulded full load displacement, in tonnes.

Craft for which  $V \geq 10 L^{0.5}$  shall be individually considered by the Society.

These Rules are intended for vessels that, in general, do not require any additional sources of electrical power for the safety of vessels other than that provided by engine driven charging generators for ship batteries. These vessels have to have a minimum of two main engines and two shaft lines.

**1.1.2** Catamarans are not covered by the present Rules.

**1.1.3** Provisions not specially covered in these Rules are to comply with applicable requirements stipulated in Rules for Steel Ships NR 467 DTM R01, Part A, Part B, Part C and Part D.

**1.1.4** Ship covered by the present Rules Note are assigned the service notation **crew boat**, as defined in Part A, Chap 1, Sec 2, [4.11.4].

### 1.2 Summary table

**1.2.1** The Sections of these Rules containing the requirements specific to crew boats are indicated in Tab 1.

**Table 1 : Summary table**

Main subject	Reference
Stability	Ch 2
Hull	Ch 3
Outfittings	Ch 4
Machinery and cargo system	Ch 5
Electrical installations	Ch 6
Fire protection, detection and extinction	Ch 7

## 2 Definitions

### 2.1

#### 2.1.1 Crew boats

Crew boats are basically vessels dedicated to transport of offshore personnel from harbours to moored offshore installations or vessels.

They may be also involved in supplying such installations with goods and stores.

They are, in general, single deck ships arranged with large superstructures forward and a broad open deck aft intended for cargo.

### 2.2 Integral tank

**2.2.1** Integral tank means a cargo containment envelope which forms part of the ship's hull and which may be stressed in the same manner and by the same loads which stress the contiguous hull structure and which is normally essential to the structural completeness of the ship's hull.

### 2.3 Operational conditions

**2.3.1** Crew boats are to be operated within operating conditions defined in Sec 3, [4.3].

**2.3.2** Operational speed is 90% of maximum speed.

## 3 General arrangement design

### 3.1 Subdivision arrangement

**3.1.1** All crew boats are to have at least the following transverse watertight bulkheads :

- one collision bulkhead
- one after peak bulkhead
- two bulkheads forming the boundaries of the machinery space in crew boats with machinery amidships, and a bulkhead forward of the machinery space in crew boats with machinery aft.

### 3.2 Collision bulkhead

**3.2.1** A collision bulkhead is to be fitted which is to be watertight up to the freeboard deck. This bulkhead is to be located at a distance from the forward perpendicular  $FP_{LL}$  of not less than 5% of the length  $L_{LL}$  of the crew boat or 10m, whichever is the less, and not more than 8% of  $L_{LL}$ , where :

- $L_{LL}$  = freeboard length, equal to the distance, in m, on the waterline at 85% of the least moulded depth from the top of keel, measure from the forward side of the stem to the centre of the rudder stock, without being less

than 96% of the total length on the same waterline.  $L_{LL}$  need not to be taken less than 50 m, unless required by the National Authorities.

### 3.3 Compartment arrangement for all ships

#### 3.3.1 Location of cargo tanks and cargo storage vessels

All cargo tanks and cargo storage vessels are to be located aft of the collision bulkhead and forward of the aft peak.

#### 3.3.2 Independent portable tanks

Independent portable tanks, to be fitted on the weather deck, may be used as cargo storage vessels subject to the following conditions:

- the portable tanks are to be securely fastened to the hull structure
- in the zone on the weather deck where the portable tanks are arranged, a suitable possibly removable containment coaming is to be fitted such as to prevent any spillage and/or leakages from flowing to gas-safe areas
- a space is to be left between tanks and ship sides sufficient to allow easy passage of ship personnel and transfer of fire-fighting arrangements
- the cargo handling system serving portable tanks is to be such that liquid heads higher than those allowable for cargo tanks, if any, served by the same system cannot occur.

Provisions are to be made such that any portable tank is easily identifiable by means of markings or suitable plates.

### 3.4 Access arrangement for all ships

#### 3.4.1 Access to spaces below the freeboard deck

Access to the areas below the freeboard deck is, in general, to be provided from a position above the deck of a first tier superstructure.

As an alternative, indirect access may be provided from a space fitted with an outer door having a sill not less than 600 mm high and a self-closing, gas-tight inner door having a sill not less than 380 mm high.

Smaller sill height could be accepted on aftwall of first tier of superstructure, provided flag agreement.

#### 3.4.2 Access to the cargo deck

Hatches, doors, etc. which give access to the cargo deck are to be kept closed during navigation and are to comply with Pt B, Ch 2, Sec 1, [6.2.4].

#### 3.4.3 Access to the machinery space

Access to the machinery space is, as far as practicable, to be arranged within the forecastle. Any access to the machinery space from the exposed cargo deck is to be provided with two weathertight closures. Access to spaces below the exposed cargo deck is preferably to be from a position within or above the superstructure deck.

#### 3.4.4 Access to spaces

For access to all spaces, the minimum spacing between cargo tank boundaries and adjacent ship's structures is to be 600 mm.

### 3.5 Accommodation

#### 3.5.1 Seating

A seat is to be provided for each personnel being carried and each crew for which the crew boat is certified to carry. Such seats are to be arranged in enclosed spaces.

## SECTION 2

## STABILITY

### 1 General

#### 1.1 Application

1.1.1 Every decked crew boats of 24 metres and over is to comply with the provisions of [2] and [3].

#### 1.2 Relaxation

1.2.1 Relaxation in the requirements of [2] and [3] may be permitted by the Society for vessels engaged in near-coastal voyages provided the operating conditions are such as to render compliance with such paragraphs unreasonable or unnecessary.

### 2 Intact stability

#### 2.1 General stability criteria

2.1.1 The stability of the ship, for the loading conditions defined in [2.2] and [2.3] with the assumptions in [2.4], is to be in compliance with the requirements of [2.5] or as an alternative with the requirements of [2.6], and [2.8]. The additional criteria of [2.7] are also to be complied with.

#### 2.2 General loading conditions

2.2.1 The standard loading conditions to be included in the trim and stability booklet are:

- lightship condition
- ship in ballast in the departure condition, without cargo but with full stores and fuel
- ship in ballast in the arrival condition, without cargo and with 10% stores and fuel remaining

#### 2.3 Additional loading conditions

2.3.1 In addition to the standard loading conditions specified in the following loading cases are to be included in the trim and stability booklet:

- ship in the fully loaded departure condition having under deck cargo, if any, and cargo specified by position and weight on deck, with full stores and fuel, corresponding to the worst service condition in which all the relevant stability criteria are met
- ship in the fully loaded arrival condition with cargo as specified above, but with 10 per cent stores and fuel.

#### 2.4 Assumptions for calculating loading conditions

2.4.1 In all cases when deck cargo is carried, a realistic stowage weight is to be assumed and stated in the stability information, including the height of the cargo and its centre of gravity.

2.4.2 Where pipes are carried on deck, a quantity of trapped water equal to a certain percentage of the net volume of the pipe deck cargoes is to be assumed in and around the pipes. The net volume is to be taken as the internal volume of the pipes, plus the volume between the pipes. This percentage is 30 if the freeboard amidships is equal to or less than 0,015 L and 10 if the freeboard amidships is equal to or greater than 0,03 L. For intermediate values of the freeboard amidships, the percentage may be obtained by linear interpolation. In assessing the quantity of trapped water, the Society may take into account positive or negative sheer aft, actual trim and area of operation.

#### 2.5 General intact stability criteria

2.5.1 The area under the righting lever curve (GZ curve) is to be not less than 0,055 m.rad up to  $\theta = 30^\circ$  angle of heel and not less than 0,09 m.rad up to  $\theta = 40^\circ$  or the angle of down flooding  $\theta_f$  if this angle is less than  $40^\circ$ . Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of  $30^\circ$  and  $40^\circ$  or between  $30^\circ$  and  $\theta_f$ , if this angle is less than  $40^\circ$ , is to be not less than 0,03 m.rad.

Note 1:  $\theta_f$  is an angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight submerge. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open. This interpretation is not intended to be applied to existing ships.

The means of closing air pipes are to be weathertight and of an automatic type if the openings of the air pipes to which the devices are fitted would be submerged at an angle of less than 40 degrees (or any lesser angle which may be needed to suit stability requirements) when the ship is floating at its summer load line draught. Pressure/vacuum valves (P.V. valves) may be accepted on tankers. Wooden plugs and trailing canvas hoses may not be accepted in positions 1 and 2.

2.5.2 The righting lever GZ is to be at least 0,20 m at an angle of heel equal to or greater than  $30^\circ$

2.5.3 The maximum righting arm is to occur at an angle of heel preferably exceeding  $30^\circ$  but not less than  $25^\circ$ .

When the righting lever curve has a shape with two maximums, the first is to be located at a heel angle not less than  $25^\circ$ .

2.5.4 The initial metacentric height GM0 is not to be less than 0,15 m.

## 2.6 Alternative stability criteria

**2.6.1** The equivalent criteria listed below are to be applied where a vessel's characteristics render compliance with [2.5] impracticable.

**2.6.2** The area, in m.rad, under the curve of righting levers (GZ curve) may not be less than 0,070 up to an angle of 15° when the maximum righting lever (GZ) occurs at 15° and 0,055 up to an angle of 30° when the maximum righting lever (GZ) occurs at 30° or above. Where the maximum righting lever (GZ) occurs at angles of between 15° and 30°, the corresponding area "A", in m.rad, under the righting lever curve is to be:

$$A = 0,055 + 0,001 \cdot (30^\circ - \theta_{\max})$$

where  $\theta_{\max}$  is the angle of heel, in degrees, at which the righting lever curve reaches its maximum.

**2.6.3** The area, in m.rad, under the righting lever curve (GZ curve) between the angles of heel of 30° and 40°, or between 30° and  $\theta_f$  if this angle is less than 40°, may not be less than 0,03, where  $\theta_f$  is defined in [2.5.1].

**2.6.4** The righting lever (GZ), in m, is to be at least 0,20 at an angle of heel equal to or greater than 30°.

**2.6.5** The maximum righting lever (GZ) is to occur at an angle of heel not less than 15°.

**2.6.6** The initial transverse metacentric height (GM), in m, may not be less than 0,15.

## 2.7 Additional criteria

**2.7.1** A minimum freeboard at the stern of at least 0,005 L is to be maintained in all operating conditions.

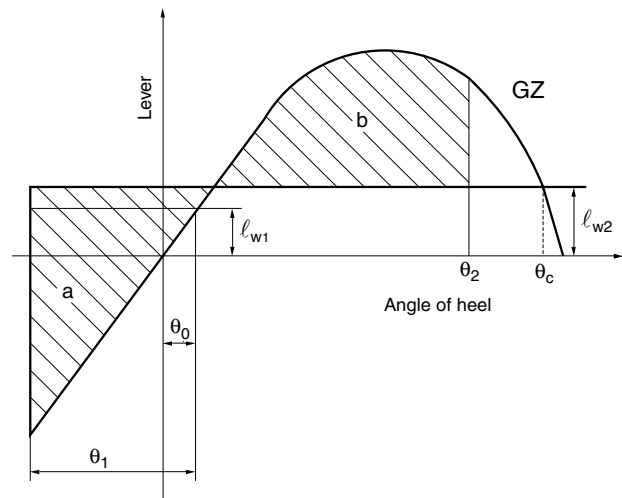
## 2.8 Weather Criterion

### 2.8.1 General

The ability of a ship to withstand the combined effects of beam wind and rolling is to be demonstrated for each standard condition of loading, with reference to Fig 1 as follows:

- the ship is subjected to a steady wind pressure acting perpendicular to the ship's centreline which results in a steady wind heeling lever ( $\ell_{w1}$ );
- from the resultant angle of equilibrium ( $\theta_0$ ), the ship is assumed to roll owing to wave action to an angle of roll ( $\theta_1$ ) to windward;
- the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever ( $\ell_{w2}$ );
- free surface effects are to be accounted for in the standard conditions of loading.

Figure 1 : Severe wind and rolling



### 2.8.2 Criteria

Under the assumptions of [2.8.1], the following criteria are to be complied with:

- the area "b" is to be equal to or greater than area "a", where:
  - a : Area above the GZ curve and below  $\ell_{w1}$ , between  $\theta_0$  and the intersection of  $\ell_{w1}$  with the GZ curve
  - b : Area above the heeling lever  $\ell_{w2}$  and below the GZ curve, between the intersection of  $\ell_{w2}$  with the GZ curve and  $\theta_c$ .
- the angle of heel under action of steady wind ( $\theta_0$ ) is to be limited to 16° or 80% of the angle of deck edge immersion, whichever is less.

### 2.8.3 Heeling levers

The wind heeling levers  $\ell_{w1}$  and  $\ell_{w2}$ , in m, referred to in [2.8.1], are constant values at all angles of inclination and are to be calculated as follows:

$$\ell_{w1} = \frac{PAZ}{1000g\Delta}$$

and

$$\ell_{w2} = 1,5 \ell_{w1}$$

where:

- P : 504 N/m<sup>2</sup> for unrestricted navigation notation. The value of P used for ships with restricted navigation notation may be reduced subject to the approval of the Society;
- A : Projected lateral area in m<sup>2</sup>, of the portion of the ship and deck cargo above the waterline;
- Z : Vertical distance in m, from the centre of A to the centre of the underwater lateral area or approximately to a point at one half the draught;
- $\Delta$  : Displacement in t;
- g = 9,81 m/s<sup>2</sup>.

### 2.8.4 Angles of heel

For the purpose of calculating the criteria of [2.8.4], the angles in Fig 1 are defined as follows:

$\theta_0$  : Angle of heel, in degrees, under action of steady wind

$\theta_1$  : Angle of roll, in degrees, to windward due to wave action, calculated as follows:

$$\theta_1 = 109kX_1X_2\sqrt{rs}$$

$\theta_2$  : Angle of downflooding ( $\theta_d$ ) in degrees, or 50° or  $\theta_c$ , whichever is less

$\theta_f$  : Angle of heel in degrees, at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open;

$\theta_c$  : Angle in degrees, of second intercept between wind heeling lever  $\ell_{w2}$  and GZ curves

$$\theta_R = \theta_0 - \theta_1$$

$X_1$  : Coefficient defined in Tab 1

$X_2$  : Coefficient defined in Tab 2

$k$  : Coefficient equal to:

$k = 1,0$  for a round-bilged ship having no bilge or bar keels

$k = 0,7$  for a ship having sharp bilge

For a ship having no bilge keels, a bar keel or both,  $k$  is defined in Tab 3.

$$r = 0,73 \pm 0,6 (OG)/T_1$$

OG : Distance in m, between the centre of gravity and the waterline (positive if centre of gravity is above the waterline, negative if it is below)

$T_1$  : Mean moulded draught in m, of the ship

$s$  : Factor defined in Tab 4.

Note 1: The angle of roll  $\theta_1$  for ships with anti-rolling devices is to be determined without taking into account the operations of these devices.

Note 2: The angle of roll  $\theta_1$  may be obtained, in lieu of the above formula, from model tests or full scale measurements.

The rolling period  $T_R$ , in s, is calculated as follows:

$$T_R = \frac{2CB}{\sqrt{GM}}$$

where:

$$C = 0,373 + 0,023 \frac{B}{T_1} - 0,043 \frac{L_W}{100}$$

The symbols in the tables and formula for the rolling period are defined as follows:

$L_W$  : Length in m, of the ship at the waterline

$T_1$  : Mean moulded draught in m, of the ship

$A_K$  : Total overall area in m<sup>2</sup> of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas, or area of the lateral projection of any hull appendages generating added mass during ship roll

GM : Metacentric height in m, corrected for free surface effect.

**Table 1 : Values of coefficient  $X_1$**

B/d	$X_1$
$\leq 2,4$	1,00
2,5	0,98
2,6	0,96
2,7	0,95
2,8	0,93
2,9	0,91
3,0	0,90
3,1	0,88
3,2	0,86
3,4	0,82
$\geq 3,5$	0,80

**Table 2 : Values of coefficient  $X_2$**

$C_B$	$X_2$
$\leq 0,45$	0,75
0,50	0,82
0,55	0,89
0,60	0,95
0,65	0,97
$\geq 0,70$	1,00

**Table 3 : Values of coefficient  $k$**

$\frac{A_K \times 100}{L \times B}$	$k$
0,0	1,00
1,0	0,98
1,5	0,95
2,0	0,88
2,5	0,79
3,0	0,74
3,5	0,72
$\geq 4,0$	0,70

**Table 4 : Values of factor  $s$**

$T_R$	$s$
$\leq 6$	0,100
7	0,098
8	0,093
12	0,065
14	0,053
16	0,044
18	0,038
$\geq 20$	0,035

(Intermediate values in these tables are to be obtained by linear interpolation)

## 2.9 Factors of influence

**2.9.1** The stability criteria mentioned in [2.5] and [2.6] are minimum values; no maximum values are recommended. It is advisable to avoid excessive values, since these might lead to acceleration forces which could be prejudicial to the vessel, its complement, its equipment and the safe carriage of cargo.

## 3 Damage stability where the additional class notation SDS has been requested

### 3.1 General

**3.1.1** Taking into account as initial conditions before flooding, the standard loading conditions as referred to in [2.2] and [2.3], the vessel is to comply with the damage stability criteria as specified in [3.7].

### 3.2 Damage dimensions

**3.2.1** The assumed extent of damage of crew boat is assumed to occur anywhere in its length between transverse watertight bulkheads spaced at a distance of not less than the longitudinal extent of side damage specified in Tab 5.

**Table 5 : Extent of damage**

Longitudinal Extent	Transverse Extent	Vertical Extent
1/3 L <sup>2/3</sup> or 14.5 m whichever is less	B/5 or 11.5 m whichever is less (1)	Full depth (2)
<p>(1) Measured inboard from the side of the vessel perpendicularly to the centreline at the level of the summer load waterline.</p> <p>(2) From the the moulded line of the bottom shell plating at centreline upwards without limit.</p>		

### 3.3 Progressive flooding

**3.3.1** If pipes, ducts trunks or tunnels are situated within the assumed extent of damage, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed to be floodable for each case of damage.

### 3.4 Minor damage

**3.4.1** If damage of a lesser extent than that specified in [3.2] results in a more severe condition, such lesser extent is to be assumed.

### 3.5 Permeabilities

**3.5.1** The permeability of spaces assumed to be damaged is to be as indicated in Tab 6.

## 3.6 Survival requirements

**3.6.1** Compliance with the requirements of [3.7] is to be confirmed by calculations which take into consideration the design characteristics of the vessel, the arrangements, configuration and permeability of the damaged compartments and the distribution, specific gravities and free surface effect of liquids.

**Table 6 : Values of permeability**

Spaces	Permeability
Appropriated to cargo	by calculation but not less than 0,60
Appropriated to stores	0,60
Occupied by accommodation	0,95
Occupied by machinery	0,85
Void spaces, empty tanks	0,95
Intended for liquids	0 or 0,95 (1)
(1) The permeability of tanks is to be consistent with the amount of liquid carried.	

### 3.7 Damage stability criteria

**3.7.1** The final waterline, taking into account sinkage, heel and trim, is to be below the lower edge of any opening through which progressive flooding may take place. Such openings include air-pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers but may exclude those openings closed by means of watertight manhole covers and flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors and sidescuttles of the non-opening type.

**3.7.2** In the final stage of flooding, the angle of heel due to unsymmetrical flooding may not exceed 7°. In the case of flooding involving the collision bulkhead the angle of heel due to unsymmetrical flooding may not exceed 12°. In special cases, additional heel maybe allowed but in no case should the final heel exceed 15°. Unsymmetrical floodings are to be kept to the minimum. The means adopted for equalization should, when practicable, be self-acting. In any case where controls to cross-flooding fittings are provided they should be operable from above the bulkhead deck. The fittings and the controls are to be submitted to the Society for approval.

**3.7.3** The initial metacentric height of the ship in the final stage of flooding for the static equilibrium position in case of symmetrical flooding and for the upright position in case of unsymmetrical flooding as calculated by constant displacement method should not be less than 0.05 m before appropriate measures to increase the metacentric height have been taken.

**3.7.4** The righting lever curve at the final stage of flooding should have a minimum range of at least 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 100 mm within this range.

Unprotected openings may not become immersed at an angle of heel within the prescribed minimum range of residual stability unless the space in question has been included as a floodable space in calculations for damage stability. Within this range, immersion of any of the openings

referred to in [3.7.1], and any other openings capable of being closed weathertight may be authorised.

**3.7.5** The stability is to be sufficient during the intermediate stages of flooding. In this regard the Society applies the same criteria relevant to the final stage of flooding also during the intermediate stages of flooding.

## SECTION 3

## HULL

### 1 Documents to be submitted

#### 1.1 General

**1.1.1** Tab 1 lists the structural plans that are to be submitted to the Society, in triplicate, for examination and approval.

**1.1.2** In addition, information relative to the following is to be submitted:

- longitudinal weight distribution and position of the longitudinal centre of gravity of the craft
- design loading conditions including:
  - still water bending moments (SWBM) distribution
  - shear force (SF) distribution
  - description of corresponding loading cases
- draught and trim of the craft at sea, at rest and at its maximum speed in calm water

- any direct calculations performed
- results of model tests and full-scale measurements.

### 2 General

#### 2.1 Introductory comments

**2.1.1** This Chapter contains the requirements for structural scantlings of the craft to which these Rules apply, i.e. to craft of length less than 45m for which  $V \geq 7,16 \Delta^{1/6}$ . Craft for which  $V \geq 10 L^{0.5}$  shall be individually considered by the Society ( $V$  in knots,  $\Delta$  in tonnes).

**2.1.2** The scantlings indicated in the following paragraphs apply to craft constructed of steel or aluminium alloy, as specified in [3].

**Table 1 : Structural plans to be submitted**

Plan	Containing information relevant to:
Midship section Main sections	<ul style="list-style-type: none"> <li>• moulded dimensions, maximum service speed <math>V</math>, design acceleration <math>a_{CG}</math> and, if known, limit wave height (see [4.3])</li> <li>• materials</li> <li>• typical structural details</li> </ul>
Longitudinal sections	<ul style="list-style-type: none"> <li>• structural details</li> <li>• openings in longitudinal girders</li> </ul>
Decks	<ul style="list-style-type: none"> <li>• typical structural details</li> <li>• openings</li> <li>• deck loads, if different from Rule loads</li> </ul>
Shell expansion	<ul style="list-style-type: none"> <li>• plating</li> <li>• materials</li> <li>• typical structural details</li> <li>• position of butt and seam welds</li> <li>• openings</li> </ul>
Machinery space structure	<ul style="list-style-type: none"> <li>• machinery mass and position of centre of gravity</li> <li>• typical structural details</li> <li>• openings</li> </ul>
Watertight bulkheads	<ul style="list-style-type: none"> <li>• openings</li> <li>• typical structural details</li> <li>• openings</li> <li>• pipe passages</li> </ul>
Deckhouses	<ul style="list-style-type: none"> <li>• materials</li> <li>• details of connections between different materials</li> <li>• typical structural details</li> </ul>
Rudder	<ul style="list-style-type: none"> <li>• rudder stock material and scantlings</li> </ul>
Propeller shaft brackets	<ul style="list-style-type: none"> <li>• materials, scantlings, welding details</li> </ul>
Equipment	<ul style="list-style-type: none"> <li>• calculation of equipment number</li> <li>• equipment specification</li> </ul>
Testing plan	<ul style="list-style-type: none"> <li>• position of air vents</li> <li>• testing pressures</li> </ul>

## 2.2 Direct calculations

**2.2.1** The Society may require direct calculations to be carried out, if deemed necessary according to the provisions of [7].

Such calculations are to be carried out based on structural modelling, loading and checking criteria described in [7]. Calculations based on other criteria may be accepted if deemed equivalent to those laid down by the Society.

## 2.3 Units

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

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

## 2.4 Definitions and symbols

**2.4.1** The definitions of the following terms and symbols are applicable throughout this Chapter and its Appendices and are not, as a rule, repeated in the different paragraphs. Definitions applicable only to certain paragraphs are specified therein.

- “Moulded base line”: The line parallel to the summer load waterline, crossing the upper side of keel plate or the top of skeg at the middle of length L.
- “Hull”: The hull is the outer boundary of the enclosed spaces of the craft, except for the deckhouses, as defined below.
- “Chine”: For hulls that do not have a clearly identified chine, the chine is the hull point at which the tangent to the hull is inclined  $50^\circ$  to the horizontal.
- “Bottom”: The bottom is the part of the hull between the keel and the chines.
- “Main deck”: The main deck is the uppermost complete deck of the hull. It may be stepped.
- “Side”: The side is the part of the hull between the chine and the main deck.
- “Deckhouse”: The deckhouse is a decked structure located above the main deck, with lateral walls inboard of the side of more than 4 per cent of the local breadth. Structure located on the main deck and whose walls are not in the same longitudinal plane as the under side shell may be regarded as a deckhouse.
- “Deadrise angle  $\alpha_d$ ”: For hulls that do not have a clearly identified deadrise angle,  $\alpha_d$  is the angle between the horizontal and a straight line joining the keel and the chine.

- “Fore end”: Hull region forward of  $0,9 L$  from the aft perpendicular.
- “Aft end”: Hull region abaft of  $0,1 L$  from the aft perpendicular.
- “Midship area”: Hull region between  $0,3 L$  and  $0,7 L$  from the aft perpendicular.

- L : Rule length, in m, equal to  $L_{WL}$  where  $L_{WL}$  is the waterline measured with the craft at rest in calm water
- FP : forward perpendicular, i.e. the perpendicular at the intersection of the waterline at draught T and the foreside of the stem
- AP : aft perpendicular, i.e. the perpendicular located at a distance L abaft of the forward perpendicular
- B : the greatest moulded breadth, in m, of the craft
- $B_w$  : the greatest moulded breadth, in m, measured on the waterline at draught T
- $B_{wm}$  : the greatest moulded breadth, in m, measured below or on the waterline at draught T
- D : depth, in m, measured vertically in the transverse section at the middle of length L from the moulded base line of the hull to the top of the deck beam at one side of the main deck (if the main deck is stepped, D will be defined in each separate case at the discretion of the Society)
- T : draught of the craft, in m, measured vertically on the transverse section at the middle of length L, from the moulded base line of the hull to the full load waterline, with the craft at rest in calm water
- $\Delta$  : moulded displacement at draught T, in sea water (mass density =  $1,025 \text{ t/m}^3$ ), in tonnes
- $C_B$  : total block coefficient, defined as follows:
- $$C_B = \frac{\Delta}{(1,025 \cdot L \cdot B_w \cdot T)}$$
- V : maximum service speed, in knots
- g : acceleration of gravity, equal to  $9,81 \text{ m/s}^2$
- LCC : longitudinal centre of gravity of the craft.

## 2.5 Protection against corrosion

**2.5.1** Scantlings stipulated in [8] assume that the materials used are chosen and protected in such a way that the strength lost by corrosion is negligible.

**2.5.2** The Shipyard is to give the Society a document specifying all the arrangements made to protect the material against corrosion at the construction stage: coating types, number and thickness of layers, surface preparation, application conditions, control after completion, anodic protection, etc.

- This document must also include maintenance arrangements to be made in service to restore and maintain the efficiency of this protection, whatever the reasons of its weakening, whether incidental or not.
- All such maintenance operations are to be listed in a book shown to the Society surveyor at each visit.

## 2.6 Rounding-off

**2.6.1** Values for thickness as deduced from formulae are to be rounded off to the nearest standard value, without such a reduction exceeding 3 per cent.

## 3 Materials and connections

### 3.1 General requirements

**3.1.1** Materials to be used in hull and equipment construction, in delivery condition, are to comply with these requirements or with specific requirements applicable to individual cases; they are to be tested in compliance with the applicable provisions.

**3.1.2** These requirements presume that welding and other cold or hot manufacturing processes are carried out in compliance with current sound working practice and relevant Society provisions. The latter, in particular, may include requirements concerning welding operations and techniques and other manufacturing processes (e.g., specific preheating before welding and/or welding or other cold or hot manufacturing processes followed by an appropriate heat treatment).

**3.1.3** Welding processes shall be approved for the specified type of material for which they are intended and with limits and conditions as stated in the applicable Society requirements.

### 3.2 Steel structures

#### 3.2.1 Steels for hull structures, forgings and castings

The provisions of NR 216 "Materials and Welding" Chapter 2 apply.

#### 3.2.2 Under thickness tolerances

The following requirements apply to the under-thickness tolerances of steel plates and wide flats.

The maximum permissible under thickness tolerance for structural hull plates and wide flats for both normal and high strength steels is 0,3 mm.

The thickness is to be measured at random locations located at least 25 mm from an edge. Local surface depressions resulting from imperfections and ground areas resulting from the elimination of defects may be disregarded.

Responsibility for maintaining the required tolerances rests with the Manufacturer, who is to carry out the necessary measurements.

#### 3.2.3 Material factor K for scantlings of structural members made of high strength steel

The value of the material factor K to be introduced into formulae to check structures given in this Chapter and in the various Appendices is a function of the minimum yield stress  $R_{eH}$  value specified for the steel to be used.

Tab 2 shows the values of the material factor K to be taken depending on the  $R_{eH}$  value of the various high strength steels for hull structures for which  $R_{eH} \leq 390$  N/mm<sup>2</sup>.

The use of steels for which  $R_{eH} > 355$  N/mm<sup>2</sup> will be considered in each separate case by the Society, which may stipulate special acceptance conditions.

If, for special structures, the use of steels for which  $R_{eH} < 235$  N/mm<sup>2</sup>, has been accepted by the Society, the material factor is to be determined by:

$$K = 235 / R_{eH}$$

In the case where the use of steels with  $R_{eH}$  values which are intermediate between those indicated in Tab 2 is allowed, the values of the material factor K may be determined by means of linear interpolation.

**Table 2 : K factor**

$R_{eH}$ (N/mm <sup>2</sup> )	K
235	1,00
315	0,78
355	0,72
390	0,70

### 3.3 Aluminium alloy structures

#### 3.3.1 Aluminium alloys for hull structures, forgings and castings

The designation of aluminium alloys used here complies with the numerical designation used in RRIAD (Registration Record of International Alloy Designation).

The characteristics of aluminium alloys to be used in the construction of aluminium crew boats are to comply with the relevant requirements of NR 216 "Materials and Welding", Chapter 3, Section 2.

As a rule, series 5000 aluminium-magnesium alloys or series 6000 aluminium-magnesium-silicon alloys (Tab 3) shall be used.

The use of series 6000 alloys or extruded platings, for parts which are exposed to sea water atmosphere, will be considered in each separate case by the Society, also taking into account the protective coating applied.

The list of aluminium alloys given in Tab 3 is not exhaustive. Other aluminium alloys may be considered, provided the specification (manufacture, chemical composition, temper, mechanical properties, welding, etc.) and the scope of application be submitted to the Society for review.

In the case of welded structures, alloys and welding processes are to be compatible and appropriate, to the satisfaction of the Society and in compliance with the relevant Rules.

For forging or castings, chemical composition and mechanical properties are to comply with the relevant requirements of NR 216 "Materials and Welding", Chapter 3, Section 2.

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

Unless otherwise specified, the Young's modulus for aluminium alloys is equal to 70000 N/mm<sup>2</sup> and the Poisson's ratio equal to 0,33.

**Table 3 : Aluminium alloys for welded construction**

Guaranteed mechanical characteristics (1)							
Aluminium alloy				Unwelded condition		Welded condition	
Alloy (2)	Temper (2)	Products	Thickness (mm)	$R_{p0,2}$ (N/mm <sup>2</sup> ) (4)	$R_m$ (N/mm <sup>2</sup> ) (5)	$R_{p0,2}'$ (N/mm <sup>2</sup> ) (4)	$R_m'$ (N/mm <sup>2</sup> ) (5)
5083	0 / H111	rolled	$t \leq 50$	125	275	125	275
	H 321	rolled	$t \leq 40$	215	305	125	275
	0	extruded	all	110	270	110	270
5086	0 / H111	rolled	all	100	240	100	240
	H 321	rolled	all	185	275	100	240
	0	extruded	all	95	240	95	240
5383	0 / H111	rolled	$t \leq 40$	145	290	145	290
	H 321	rolled	$t \leq 40$	220	305	145	290
5059	0 / H111	rolled	$t \leq 40$	155	300	155	300
	H 321	rolled	$t \leq 20$	270	370	155	300
		rolled	$20 < t \leq 40$	260	360	155	300
5454	0 / H111	rolled	all	85	215	85	215
	F	rolled	all	100	210	100	210
5754	0 / H111	rolled	$t \leq 6$	80	190	80	190
			$t > 6$	70	190	70	190
6005	T5 / T6	closed extrusions	$t \leq 6$	215	255	105	165
			$6 < t \leq 25$	200	250	100	165
		open extrusions	$t \leq 10$	215	260	95	165
			$10 < t \leq 25$	200	250	80	165
6060 (3)	T5	extruded	$t \leq 6$	150	190	65	115
			$6 < t \leq 25$	130	180	65	110
6061	T6	extruded	$t \leq 25$	240	260	115	155
6082	T6	extruded	$t \leq 15$	255	310	115	170
6106	T5	extruded	$t \leq 6$	195	240	65	130
6351	T5	extruded	$t \leq 25$	240	260	140	165

(1) The guaranteed mechanical characteristics in this Table correspond to general standard values. For more information, refer to the minimum values guaranteed by the product supplier. Higher values may be accepted on the basis of welding tests including recurrent workmanship test at the shipyard only.

(2) Other grades or tempers may be considered, subject to the Society's agreement.

(3) 6060 alloy is not to be used for structural members sustaining impact loads (e.g. bottom longitudinals). The use of alloy 6106 is recommended in that case.

(4)  $R_{p0,2}$  and  $R_{p0,2}'$  are the minimum guaranteed yield stresses at 0,2% in unwelded and welded condition respectively.

(5)  $R_m$  and  $R_m'$  are the minimum guaranteed tensile strengths in unwelded and welded condition respectively.

### 3.3.2 Extruded platings

Extrusions with built-in plating and stiffeners, referred to as extruded plating, may be used.

In general, the application is limited to decks and deck-houses. Other uses may be permitted at the discretion of the Society.

Extruded plating is preferably to be oriented so that the stiffeners be parallel to the direction of main stresses.

Connections between extruded plating and primary members are to be given special attention.

### 3.3.3 Tolerances

The under-thickness tolerances of plates and rolled sections are to be in accordance with Tab 4.

The under-thickness tolerances of extruded platings are to be in accordance with Tab 5, but not taken greater than 7% of the as-built thickness. Otherwise, the reduced plate thickness has to be considered.

The responsibility for maintaining the required tolerances lies with the manufacturer, who shall also inspect the surface condition.

**Table 4 : Plates and rolled sections**

As-built thickness (mm)	Under-thickness tolerance (mm)
$t \leq 8$	0,3
$8 < t \leq 12$	0,5
$12 < t \leq 20$	0,7
$t > 20$	1,0

**Table 5 : Extruded platings**

As-built thickness (mm)	Under-thickness tolerance (mm)
$t \leq 6$	0,3
$6 < t \leq 10$	0,4

### 3.3.4 Influence of welding on mechanical characteristics

Welding heat input lowers locally the mechanical strength of aluminium alloys hardened by work hardening (series 5000 other than condition 0 or H111) or by heat treatment (series 6000).

Consequently, where necessary, a drop in mechanical characteristics of welded structures is to be considered in the heat-affected zone, with respect to the mechanical characteristics of the parent material.

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

Aluminium alloys of series 5000 in 0 condition (annealed) or in H111 condition (annealed flattened) are not subject to a drop in mechanical strength in the welded areas.

Aluminium alloys of series 5000 other than condition 0 or H111 are subjected to a drop in mechanical strength in the welded areas. The mechanical characteristics to consider in welded condition are, normally, those of condition 0 or H111, except otherwise indicated in Tab 3. Higher mechanical characteristics may be taken into account, provided they are duly justified.

Aluminium alloys of series 6000 are subject to a drop in mechanical strength in the vicinity of the welded areas. The mechanical characteristics to be considered in welded condition are, normally, to be indicated by the supplier, if not indicated in Tab 3.

### 3.3.5 Material factor K for scantlings of structural members made of aluminium alloy

The value of the material factor K to be introduced into formulae for checking scantlings of structural members, given in this Chapter and the various Appendices, is determined by the following equation:

$$K = \frac{100}{R'_{lim}}$$

where:

$R'_{lim}$  : minimum guaranteed yield stress of the parent metal in welded condition  $R'_{p0,2r}$  in N/mm<sup>2</sup>, but not to be taken greater than 70% of the minimum guaranteed tensile strength of the parent metal in welded condition  $R'_{m}$ , in N/mm<sup>2</sup> (Tab 3).

For welded constructions in hardened aluminium alloys (series 5000 other than condition 0 or H111 and series 6000), greater characteristics than those in welded condition may be considered, provided that welded connections are located in areas where stress levels are acceptable for the alloy considered in annealed or welded condition.

In case of welding of two different aluminium alloys, the material factor K to be considered for the scantlings of welds is to be the greater material factor of the aluminium alloys of the assembly.

### 3.3.6 Strength of welding

The effective length in mm of the lines of welding is given by:

$$d_e = d - 20$$

where d is the actual length in mm of the line of welding.

### 3.3.7 Riveted connections for aluminium alloy hulls

Use of rivets for connecting structures is limited, in principle, only to members which do not contribute to the overall strength of the hull. Exceptions are to be supported by experimental evidence or good in-service performance.

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

The requirements of Rules for Aluminium Alloy Ships NR 384 DNC R01, Chapter 12, Section 12-20 are to be complied with.

Whenever riveted connections are to be employed, a detailed plan, illustrating the process, as well as the dimensions and location of rivets and holes, together with the mechanical and metallurgical properties of the rivets, is to be submitted for approval.

The Society may, at its discretion, require tension, compression and shear tests to be carried out on specimens of riveted connections constructed under the same conditions as during actual hull construction, to be witnessed by a Society surveyor.

The Society reserves the right to accept the results of tests performed by recognized bodies or other Societies.

## 3.4 Welding connections

### 3.4.1 General requirements

Welding procedures already approved by the Society are to be used. In addition, individual builders are to hold an authorization by the Society to use these procedures, employing welders qualified by the Society.

For welds design and throat thicknesses, the applicable requirements of the Society Rules apply :

- Rules for Steel Ships NR 467 DTM R01, Part B, Chapter 12, Section 1 for steel structures
- Rules for Aluminium Alloy Ships NR 384 DNC R01, Chapter 12, Section 12-20 for aluminium structures

In addition, intermittent welds are not allowed in following zones:

- structure in way of shaft brackets or propellers
- structure in way of stabilisation devices such as foils, interceptors or tabs
- structure submitted to water impact

### 3.4.2 Accessibility and edge preparation

For correct execution of welded joints, sufficient accessibility is necessary, depending on the welding process adopted and the welding position.

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

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

Edge preparation, alignment of joints, spot-welding methods and root chipping are to be appropriate to the type of joint and welding position, and comply with Society Rule requirements for the welding procedures adopted.

### 3.4.3 Inspections

For aluminium structures, the inspections of welded connections by the Society surveyors are, in general, to comply with requirements of Rules for Aluminium Alloy Ships NR 384 DNC R01, Chapter 12, Annex 12-E.

For steel structures, the inspections of welded connections by the Society surveyors are, in general, to comply with requirements of Rules for Steel Ships NR 467 DTM R01, Part B, Chapter 12, Section 1, paragraph 6.

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

### 3.4.4 Welding processes for light alloys

In general, the welding of the hull structures is to be performed with the MIG (metal-arc inert gas) and TIG (tungsten-arc inert gas) processes using welding consumables recognized as suitable for the base material to be used. Welding processes and filler materials other than those above are to be individually considered by the Society at the time of the approval of welding procedures.

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

- grade and temper of parent and filler materials
- weld execution procedures: type of joint (e.g. butt-joint, fillet joint); edge preparation (e.g. thicknesses, bevelling,

right angle edges); welding position (e.g. flat, vertical, horizontal) and other parameters (e.g. voltage, amperage, gas flow capacity)

- welding conditions (e.g. cleaning procedures of edges to be welded, protection from environmental atmosphere)
- special operating requirements for butt-joints, for example for plating: welding to be started and completed on end pieces outside the joint, back chipping, arrangements for repairs consequent to possible arc restarts
- type and extent of controls during production.

## 3.5 Corrosion protection - heterogeneous steel/aluminium alloy assembly

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

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

**3.5.3** Any heterogeneous jointing system is subject to the Society's agreement.

**3.5.4** The use of transition joints made of aluminium/steel-cladded plates or profiles is subject to the Society's agreement.

**3.5.5** Transition joints are to be type-approved.

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

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

## 4 Design acceleration

### 4.1 Vertical acceleration at LCG

**4.1.1** The design vertical acceleration at LCG,  $a_{CG}$  (expressed in g), is defined by the designer and corresponds to the average of the 1 per cent highest accelerations in the most severe sea conditions expected, in addition to the gravity acceleration.

As a rule, it is to be not less than:

$$a_{CG} = f_{oc} \cdot Soc \cdot \frac{V}{\sqrt{L}}$$

where  $f_{oc}$  and  $Soc$  values are indicated in Tab 6 and Tab 7.

**Table 6 :  $f_{oc}$  values**

Type of service	Crew boats
$f_{oc}$	0.85

Table 7 : Soc values

Sea area	Open sea	Restricted open sea	Moderate environment	Smooth sea
Soc	$C_F$ (1)	0,30	0,23	0,14
(1) $C_F = 0,2 + \frac{0,6}{V/\sqrt{L}} \geq 0,32$				

**4.1.2** Lower  $a_{CG}$  values may be accepted at the Society's discretion, if justified, on the basis of model tests and/or full-scale measurements.

**4.1.3** The sea areas referred to in Tab 7 are defined with reference to significant wave heights  $H_s$  which are exceeded for an average of not more than 10 percent of the year:

- Open-sea service:  
 $H_s \geq 4,0$  m
- Restricted open-sea service:  
 $2,5$  m  $\leq H_s < 4,0$  m
- Moderate environment service:  
 $0,5$  m  $< H_s < 2,5$  m
- Smooth sea service:  
 $H_s \leq 0,5$  m.

**4.1.4** If the design acceleration cannot be defined by the designer, the  $a_{CG}$  value corresponding to the appropriate values of  $f_{oc}$  and  $S_{oc}$  reported in Tab 6 and Tab 7 will be assumed.

**4.1.5** An acceleration greater than  $a_{CG} = 1,5g$  may not be adopted for the purpose of defining limit operating conditions and scantlings.

**4.1.6** The longitudinal distribution of vertical acceleration along the hull is given by:

$$a_v = k_v \cdot a_{CG}$$

where:

$k_v$  : longitudinal distribution factor, not to be less than (see Fig 1):

$$k_v = 1 \text{ for } x/L \leq 0,5$$

$$k_v = 2 \cdot x/L \text{ for } x/L > 0,5$$

Higher values may be requested based on pitch consideration.

$a_{CG}$  : design acceleration at LCG.

**4.1.7** Variation of  $a_v$  in the transverse direction may generally be disregarded.

## 4.2 Transverse acceleration

**4.2.1** Transverse acceleration is defined on the basis of results of model tests and full-scale measurements, considering their characteristic value as specified in [4.3.1].

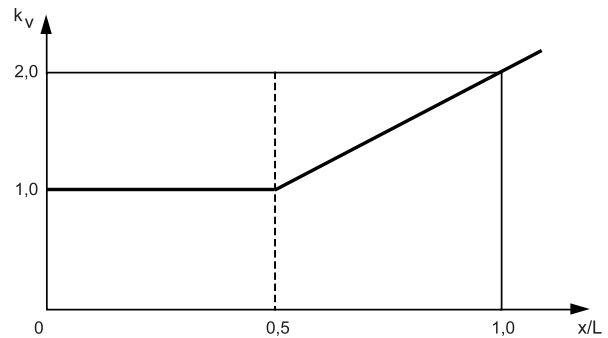
**4.2.2** In the absence of such results, transverse acceleration, in  $g$ , at the calculation point of the craft may be obtained from:

$$a_t = 2,5 \cdot \frac{H_{sl}}{L} \cdot \left(1 + 5 \cdot \left(1 + \frac{V/(\sqrt{L})}{6}\right)^2 \cdot \frac{r}{L}\right)$$

where:

$H_{sl}$  : permissible significant wave height at maximum service speed  $V$  (see [3.4.3]),

$r$  : distance from the point to  $0,5 D$

Figure 1 :  $k_v$  factor

## 4.3 Assessment of limit operating conditions

### 4.3.1 General

- "Limit operating conditions" in this paragraph are to be taken to mean sea states (characterized only by their significant wave heights) compatible with the structural design parameters of the craft, i.e. the sea states in which the craft may operate depending on its actual speed.
- Limit operating conditions are derived from the restrictions presented in [4.3.2] and [4.3.3] below.
- It is the designer's responsibility to specify the format and the values of the limit operating conditions. Their format may be for example a relationship between speed and significant wave height which ascertains actual loads less than the one used for structural design.
- The limit operating conditions must include the maximum allowed significant wave height  $H_{sm}$  consistent with the structural strength. When such design value is not available, the formula given in h) may be used. The value of  $H_{sm}$  is to be consistent with the wave height upper limit corresponding to the sea area considered for structural design, according to [4.1.3]
- Other specific design parameters influenced by sea state and speed could be also considered at the discretion of the Society.
- The limit operating conditions are defined, at the discretion of the Society, on the basis of results of model tests and full-scale measurements or by numerical simulations.
- The limit operating conditions, taken as a basis for classification, are indicated in the Classification Certificate. These limit operating conditions must be put at the disposal of the crews operating the crew boat (display at the wheelhouse is recommended).

- h) It is assumed that, on the basis of weather forecast, the craft does not encounter, within the time interval required for the voyage, sea states with significant heights, in m, greater than  $H_{sm}$ .

When  $H_{sm}$  is not available, following formula may be used :

$$H_{sm} = 5 \cdot \frac{a_{CG}}{V/(\sqrt{L})} \cdot \frac{L}{6 + 0,14 \cdot L}$$

where vertical acceleration  $a_{CG}$  is defined in [4.1].

- i) For craft with a particular shape or other characteristics, the Society reserves the right to require model tests or full-scale measurements to verify results obtained by the above formula.

#### 4.3.2 Limitation imposed by bottom impact pressure and deck loads

- a) Bottom impact pressure, given in [6.3], and deck loads, given in [6.7], are explicitly or implicitly depending on the vertical acceleration at LCG. Therefore, the design values of these loads, taken as the basis for the classification, directly impose limitation on vertical acceleration level at LCG.
- b) It is the designer's responsibility to provide for a relation between the speed and the significant wave height that provides a maximum vertical acceleration less than the design value.
- c) Model tests if any are to be carried out in irregular sea conditions with a significant wave height corresponding to the operating conditions of the craft and a clearly specified sea spectrum. The scale effect is to be accounted for with an appropriate margin of safety. The characteristic value of acceleration and global loads to be assumed corresponds to the average of the 1 per cent highest values obtained during tests. The duration of the test is, as far as practicable, to be sufficient to guarantee that results are stationary.
- d) Where model test results or full-scale measurements are not available, the formula given in e) may be used to define maximum speeds compatible with design acceleration, depending on sea states having a significant height  $H_s$ .
- e) The significant wave height is related to the craft's geometric and motion characteristics and to the vertical acceleration  $a_{CG}$  by the following formula:

$$a_{CG} = \frac{(50 - \alpha_{dCG}) \cdot \left(\frac{\tau}{16} + 0,75\right)}{3555 \cdot C_B} \cdot \left(\frac{H_s}{T} + 0,084 \cdot \frac{B_W}{T}\right) \cdot K_{FR} \cdot K_{HS}$$

- for units for which

$$V / L^{0,5} \geq 3 \text{ and } \Delta / (0,01 \cdot L)^3 \geq 3500$$

$$K_{FR} = \left(\frac{V_x}{\sqrt{L}}\right)^2$$

and

$$K_{HS} = 1$$

- for units for which

$$V/L^{0,5} < 3 \text{ or } \Delta/(0,01 \cdot L)^3 < 3500$$

$$K_{FR} = 0,8 + 1,6 \cdot \frac{V_x}{\sqrt{L}}$$

and

$$K_{HS} = \frac{H_s}{T}$$

where:

- $H_s$  : significant wave height, in m,  
 $\alpha_{dCG}$  : deadrise angle, in degrees, at LCG, to be taken between  $10^\circ$  and  $30^\circ$ ,  
 $\tau$  : trim angle during navigation, in degrees, to be taken not less than  $4^\circ$ ,  
 $V$  : maximum service speed, in knots.  
 $V_x$  : actual craft speed, in knots.

If  $V_x$  is replaced by the maximum service speed  $V$  of the craft, the previous formula yields the significant height of the limit sea state,  $H_{sl}$ . This formula may also be used to specify the permissible speed in a sea state characterised by a significant wave height equal to or greater than  $H_{sl}$ .

- f) On the basis of the formula indicated in e), the limit sea state may be defined (characterised by its significant wave height  $H_{sl}$ ), i.e. the sea state in which the craft may operate at its maximum service speed. During its voyage, whenever the craft encounters waves having a significant height greater than  $H_{sl}$ , it has to reduce its speed.
- g) The reduction of vertical acceleration  $a_{CG}$  induced by stabilisation system if any is to be disregarded for the purpose of limit operating conditions imposed by bottom impact loads.

#### 4.3.3 Limitation imposed by global loads

The longitudinal bending moment and shear forces as given in [5.2] are explicitly or implicitly depending on vertical acceleration along the ship. Therefore, the design values of these loads, taken as the basis for classification, directly impose limitation on vertical acceleration level at LCG. The requirements of b) to g) apply.

The reduction of vertical acceleration along the ship induced by stabilisation system if any is to be disregarded for the purpose of limit operating conditions imposed by global loads.

#### 4.3.4 Hull monitoring

The Society may require a hull monitoring system to be fitted on board, allowing to monitor and display in real time the vertical acceleration and any other sensitive parameter with respect to the strength.

The information is to be available at the wheelhouse and displayed in a clear format allowing to compare with design values.

When a hull monitoring system is requested, its specification is to be submitted for review.

## 5 Overall loads

### 5.1 General

**5.1.1** As a rule, only longitudinal vertical bending moment and shear force are to be considered for monohulls.

**5.1.2** For large craft, values from model tests, or hydrodynamic calculations, may be taken into account, after agreement of the Society on the methodology, the sea conditions and the loading cases. In such cases, values given in [5.2] must be considered as short term 1/100° values.

### 5.2 Bending moment and shear force

#### 5.2.1 General

- The values of the longitudinal bending moment and shear force are given, in first approximation, by the formula in [5.2.2], [5.2.3] and [5.2.4].
- The total bending moments  $M_{bIH}$ , in hogging conditions, and  $M_{bIS}$ , in sagging conditions, in kN.m, are to be taken as the greatest of those given by the formulae in [5.2.2] and [5.2.3].  
The total shear forces  $T_{bl}$ , in kN, is given by the formula in [5.2.4].
- The longitudinal distribution of the total bending moment  $M_{bIH}$  and  $M_{bIS}$  is given in [5.2.5].

#### 5.2.2 Bending moment due to still water loads, wave induced loads and impact loads

$$M_{bIH} = M_{bIS} = 0,55 \cdot \Delta \cdot L \cdot (C_B + 0,7) \cdot (1 + a_{CG})$$

where  $a_{CG}$  is the vertical acceleration at the LCG, defined in [4.1].

#### 5.2.3 Bending moment due to still water loads and wave induced loads

$$M_{bIH} = M_{sH} + 0,60 \cdot Soc \cdot C \cdot L^2 \cdot B \cdot C_B$$

$$M_{bIS} = M_{sS} + 0,35 \cdot Soc \cdot C \cdot L^2 \cdot B \cdot (C_B + 0,7)$$

where:

- $M_{sH}$  : still water hogging bending moment, in kN.m,
- $M_{sS}$  : still water sagging bending moment, in kN.m,
- $Soc$  : parameter as indicated in Tab 7, for the considered type of service.

$$C = 6 + 0,02 L$$

For the purpose of this calculation,  $C_B$  may not be taken less than 0,6.

#### 5.2.4 Total shear force

$$T_{bl} = \frac{3,2 \cdot M_{bl}}{L}$$

where:

- $M_{bl}$  the greatest between  $M_{bIH}$  and  $M_{bIS}$ , calculated according to [5.2.2] and [5.2.3], as applicable.

#### 5.2.5 Longitudinal distribution of total bending moment

The longitudinal distribution of the total bending moments is given by:

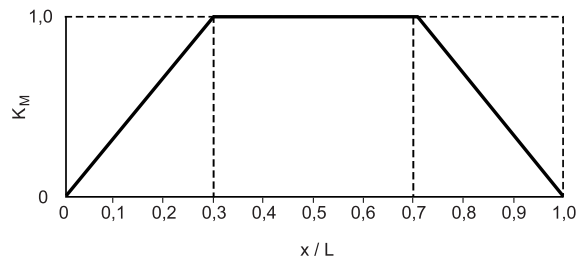
$K_M \cdot M_{bIH}$  in hogging

$K_M \cdot M_{bIS}$  in sagging

where:

$K_M$  : longitudinal distribution factor as shown on Fig 2.

Figure 2 :  $K_M$  factor



## 6 Local loads

### 6.1 Introduction

**6.1.1** Design loads defined in this Article are to be used for the resistance checks provided for in [8] to obtain scantlings of structural elements of hull and deckhouses.

**6.1.2** Such loads may be integrated or modified on the basis of the results of model tests or full-scale measurements. Model tests are to be carried out in irregular sea conditions with significant wave heights corresponding to the operating conditions of the craft. The scale effect is to be accounted for by an appropriate margin of safety.

**6.1.3** The characteristic value to be assumed is defined as the average of the 1 per cent highest values obtained during testing. The length of the test is, as far as practicable, to be sufficient to guarantee that statistical results are stationary.

### 6.2 Loads

#### 6.2.1 General

The following loads are to be considered in determining scantlings of hull structures:

- impact pressures due to slamming, if expected to occur,
- sea pressures due to hydrostatic heads and wave loads,
- internal loads.

External pressure generally determines scantlings of side and bottom structures; internal loads generally determine scantlings of deck structures.

Where internal loads are caused by concentrated masses of significant magnitude (e.g. tanks, machinery), the capacity of the side and bottom structures to withstand such loads is to be verified according to criteria stipulated by the Society. In such cases, the inertial effects due to acceleration of the craft are to be taken into account.

Such verification is to disregard the simultaneous presence of any external wave loads acting in the opposite direction to internal loads.

## 6.2.2 Load points

Pressure on panels and strength members may be considered uniform and equal to the pressure at the following load points:

- for panels:
  - lower edge of the plate, for pressure due to hydrostatic head and wave load
  - geometrical centre of the panel, for impact pressure
- for strength members:
  - centre of the area supported by the element.

Where the pressure diagram shows cusps or discontinuities along the span of a strength member, a uniform value is to be taken on the basis of the weighted mean value of pressure calculated along the length.

## 6.3 Impact pressure on the bottom of hull

**6.3.1** If slamming is expected to occur, the impact pressure, in kN/m<sup>2</sup>, considered as acting on the bottom of hull is not less than:

$$p_{sl} = 70 \cdot \frac{\Delta}{S_r} \cdot K_1 \cdot K_2 \cdot K_3 \cdot a_{CG}$$

where:

$\Delta$  : displacement, in tonnes (see [2.4.1])

$S_r$  : reference area, m<sup>2</sup>, equal to:

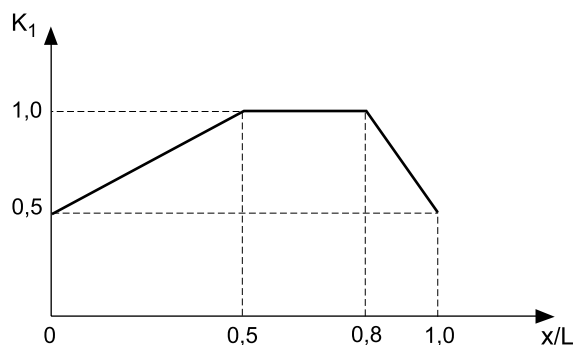
$$S_r = 0,7 \cdot \frac{\Delta}{T}$$

$K_1$  : longitudinal bottom impact pressure distribution factor (see Fig 3):

- for  $x/L < 0,5$ :  $K_1 = 0,5 + x/L$
- for  $0,5 \leq x/L \leq 0,8$ :  $K_1 = 1,0$
- for  $x/L > 0,8$ :  $K_1 = 3,0 - 2,5 \cdot x/L$

where  $x$  is the distance, in m, from the aft perpendicular to the load point

**Figure 3 : Impact area factor**



$K_2$  : factor accounting for impact area, equal to:

$$K_2 = 0,455 - 0,35 \cdot \frac{u^{0,75} - 1,7}{u^{0,75} + 1,7}$$

with:

- $K_2 \geq 0,50$  for plating,
- $K_2 \geq 0,45$  for stiffeners,
- $K_2 \geq 0,35$  for girders and floors,

$$u = 100 \cdot \frac{s}{S_r}$$

where  $s$  is the area, in m<sup>2</sup>, supported by the element (plating, stiffener, floor or girder). For plating, the supported area is the spacing between the stiffeners multiplied by their span, without taking for the latter more than three times the spacing between the stiffeners

$K_3$  : factor accounting for shape and deadrise of the hull, equal to:

$$K_3 = (70 - \alpha_d) / (70 - \alpha_{dCG})$$

where  $\alpha_{dCG}$  is the deadrise angle, in degrees, measured at LCG and  $\alpha_d$  is the deadrise angle, in degrees, between horizontal line and straight line joining the edges of respective area measured at the longitudinal position of the load point; values taken for  $\alpha_d$  and  $\alpha_{dCG}$  are to be between 10° and 30°

$a_{CG}$  : design vertical acceleration at LCG, defined in [4.1].

## 6.4 Sea pressures

### 6.4.1 Sea pressure on bottom and side shell

a) The sea pressure, in kN/m<sup>2</sup>, considered as acting on the bottom and side shell is not less than  $p_{smin}$ , defined in Tab 12, nor less than:

- for  $z \leq T$ :

$$p_s = 10 \cdot \left( T + 0,75 \cdot S - \left( 1 - 0,25 \cdot \frac{S}{T} \right) \cdot z \right)$$

- for  $z > T$ :

$$p_s = 10 \cdot (T + S - z)$$

where:

$z$  : vertical distance, in m, from the moulded base line to load point.  $z$  is to be taken positively upwards,

$S$  : as given, in m, in Tab 12 with  $C_B$  taken not greater than 0,5.

b) Between midship area and fore end ( $0,5 < x/L < 0,9$ ),  $p_s$  varies in a linear way as follows:

$$p_s = p_{sFP} - (2,25 - 2,5 \cdot x/L) \cdot (p_{sFP} - p_{sM})$$

where  $p_{sFP}$  is the sea pressure at fore end and  $p_{sM}$  in midship area.

Table 8 : Values of S and  $p_{smin}$ 

	S	$p_{smin}$
$x/L \geq 0,9$	$T \leq 0,36 \cdot a_{CG} \cdot \frac{\sqrt{L}}{C_B} \leq 3,5 \cdot T$	$20 \leq \frac{L+75}{5} \leq 35$
$x/L \leq 0,5$	$T \leq 0,60 \cdot a_{CG} \cdot \sqrt{L} \leq 2,5 \cdot T$	$10 \leq \frac{L+75}{10} \leq 20$

## 6.5 Sea pressures on front walls of the hull

**6.5.1** The pressure, kN/m<sup>2</sup>, considered as acting on front walls of the hull (in case of stepped main deck), not located at the fore end, is not less than:

$$p_{sf} = 6 \cdot \left(1 + \frac{x_1}{2 \cdot L(C_B + 0,1)}\right) (1 + 0,045 \cdot L - 0,38 \cdot z_1)$$

where:

$x_1$  : distance, in m, from front walls to the midship perpendicular (for front walls aft of the midship perpendicular,  $x_1$  is equal to 0),

$z_1$  : distance, in m, from load point to waterline at draught T.

Where front walls are inclined backwards, the pressure calculated above can be reduced to ( $p_{sf} \sin \alpha$ ), where  $\alpha$  is the angle in degree between front wall and deck.

$p_{sf}$  is not less than the greater of:

$$3 + (6,5 + 0,06 \cdot L) \cdot \sin \alpha$$

$$3 + 2,4 \cdot a_{CG}$$

**6.5.2** For front walls located at the fore end, the pressure  $p_{sf}$  will be individually considered by the Society.

## 6.6 Sea pressures on deckhouses

**6.6.1** The pressure, kN/m<sup>2</sup>, considered as acting on walls of deckhouses is not less than:

$$p_{su} = K_{su} \cdot \left(1 + \frac{x_1}{2 \cdot L(C_B + 0,1)}\right) (1 + 0,045 \cdot L - 0,38 \cdot z_1)$$

where:

$K_{su}$  : coefficient equal to:

- for front walls of a deckhouse located directly on the main deck not at the fore end:

$$K_{su} = 6,0$$

- for unprotected front walls of the second tier, not located at the fore end:

$$K_{su} = 5,0$$

- for sides of deckhouses, b being the breadth, in m, of the considered deckhouse:

$$K_{su} = 1,5 + 3,5 \cdot b/B \text{ (with } 3 \leq K < 5)$$

- for the other walls:

$$K_{su} = 3,0$$

$x_1$  : distance, in m, from front walls or from wall elements to the midship perpendicular (for front walls or side walls aft of the midship perpendicular,  $x_1$  is equal to 0),

$z_1$  : distance, in m, from load point to waterline at draught T.

**6.6.2** The minimum values of  $p_{su}$ , in kN/m<sup>2</sup>, to be considered are:

- for the front wall of the lower tier:

$$p_{su} = 6,5 + 0,06 \cdot L$$

- for the sides and aft walls of the lower tier:

$$p_{su} = 4,0$$

- for the other walls or sides:

$$p_{su} = 3,0$$

**6.6.3** For unprotected front walls located at the fore end, the pressure  $p_{su}$  will be individually considered by the Society.

## 6.7 Deck loads

### 6.7.1 General

The pressure, in kN/m<sup>2</sup>, considered as acting on decks is given by the formula:

$$p_d = p (1 + 0,4 \cdot a_v)$$

where:

$p$  : uniform pressure due to the load carried, kN/m<sup>2</sup>. Minimum values are given in [6.7.2] to [6.7.6],

$a_v$  : design vertical acceleration, defined in [4.1].

Where decks are intended to carry masses of significant magnitude, including vehicles, the concentrated loads transmitted to structures are given by the corresponding static loads multiplied by  $(1 + 0,4 a_v)$ .

### 6.7.2 Weather decks and exposed areas

a) For weather decks and exposed areas without deck cargo:

- if  $z_d \leq 2$ :  
 $p = 6,0$  kN/m<sup>2</sup>
- if  $2 < z_d < 3$ :  
 $p = (12 - 3 z_d)$  kN/m<sup>2</sup>
- if  $z_d \geq 3$ :  
 $p = 3,0$  kN/m<sup>2</sup>

where  $z_d$  is the vertical distance, in m, from deck to waterline at draught T.

$p$  can be reduced by 20% for primary supporting members and pillars under decks located at least 4 m above the waterline at draught T, excluding embarkation areas.

b) For weather decks and exposed areas with deck cargo:

- if  $z_d \leq 2$ :  
 $p = (p_c + 2)$  kN/m<sup>2</sup>, with  $p_c \geq 4,0$  kN/m<sup>2</sup>
- if  $2 < z_d < 3$ :  
 $p = (p_c + 4 - z_d)$  kN/m<sup>2</sup>, with  $p_c \geq (8,0 - 2 z_d)$  kN/m<sup>2</sup>
- if  $z_d \geq 3$ :  
 $p = (p_c + 1)$  kN/m<sup>2</sup>, with  $p_c \geq 2,0$  kN/m<sup>2</sup>

where:

$z_d$  : distance defined in [6.7.2] a),

$p_c$  : uniform pressure due to deck cargo load, in  $\text{kN/m}^2$ , to be defined by the designer with the limitations indicated above.

### 6.7.3 Sheltered decks

They are decks which are not accessible to the passengers and which are not subjected to the sea pressures. Crew can access such deck with care and taking account of the admissible load, which is to be clearly indicated. Deck-houses protected by such decks may not have direct access to 'tween-deck below.

For shelter decks:

$$p = 1,3 \text{ kN/m}^2$$

A lower value may be accepted, at the discretion of the Society, provided that such a value as well as the way of access to the deck are clearly specified by and agreed upon with the Owner.

### 6.7.4 Enclosed accommodation decks

a) For enclosed accommodation decks not carrying goods:

$$p = 3,0 \text{ kN/m}^2$$

$p$  can be reduced by 20 per cent for primary supporting members and pillars under such decks.

b) For enclosed accommodation decks carrying goods:

$$p = p_c$$

The value of  $p_c$  is to be defined by the designer, but taken as not less than  $3,0 \text{ kN/m}^2$ .

### 6.7.5 Enclosed cargo decks

For enclosed cargo decks other than decks carrying vehicles:

$$p = p_c$$

where  $p_c$  is to be defined by the designer, but taken as not less than  $3,0 \text{ kN/m}^2$ .

For enclosed cargo decks carrying vehicles, the loads are defined in [6.7.7].

### 6.7.6 Platforms of machinery spaces

For platforms of machinery spaces:

$$p = 15,0 \text{ kN/m}^2$$

### 6.7.7 Decks carrying vehicles

a) The scantlings of the structure of decks carrying vehicles are to be determined by taking into account only the concentrated loads transmitted by the wheels of vehicles, except in the event of supplementary requirement from the designer.

b) The scantlings under racking effects (e.g. for combined loading condition 3 defined in [7.2.9]) of the primary structure of decks carrying vehicles is to be the greater of the following cases:

- scantlings determined under concentrated loads transmitted by the wheels of vehicles,
- scantlings determined under a uniform load  $p_c$  taken not less than  $2,5 \text{ kN/m}^2$ . This value of  $p_c$  may be increased if the structural weight cannot be considered as negligible, to the satisfaction of the Society.

## 6.8 Pressures on tank structures

**6.8.1** The pressure, in  $\text{kN/m}^2$ , considered as acting on tank structures is not less than the greater of:

$$p_{t1} = 9,81 \cdot h_1 \cdot \rho \cdot (1 + 0,4 \cdot a_v) + 100 \cdot p_v$$

$$p_{t2} = 9,81 \cdot h_2$$

where:

$h_1$  : distance, in m, from load point to tank top,

$h_2$  : distance, in m, from load point to top of overflow or to a point located 1,5 m above the tank top, whichever is greater,

$\rho$  : liquid density, in  $\text{t/m}^3$  ( $1,0 \text{ t/m}^3$  for water),

$p_v$  : setting pressure, in bars, of pressure relief valve, when fitted.

## 6.9 Pressures on subdivision bulkheads

**6.9.1** The pressure, in  $\text{kN/m}^2$ , considered as acting on subdivision bulkheads is not less than:

$$p_{sb} = 9,81 \cdot h_3$$

where:

$h_3$  : distance, in m, from load point to bulkhead top.

## 7 Direct calculations

### 7.1 General

**7.1.1** Direct calculations generally require to be carried out, in the opinion of the Society, to check primary structures for craft with speed  $V > 45$  knots.

**7.1.2** In addition, direct calculations are to be carried out to check scantlings of primary structures of craft whenever, in the opinion of the Society, hull shapes and structural dimensions are such that scantling formulas in 3.8 are no longer deemed to be effective.

**7.1.3** This may be the case, for example, in the following situations:

- elements of the primary transverse ring (beam, web and floor) have very different cross section inertiae, so that the boundary conditions for each are not well-defined,
- marked V-shapes, so that floor and web tend to degenerate into a single element,
- complex, non-conventional geometries,
- presence of significant racking effects (in general on ferries),
- structures contributing to longitudinal strength with large windows in side walls.

### 7.2 Loads

**7.2.1** In general, the loading conditions specified in [7.2.6] to [7.2.9] below are to be considered.

Condition [7.2.9] is to be checked for craft for which, in the opinion of the Society, significant racking effects are anticipated.

**7.2.2** In relation to special structure or loading configurations, should some loading conditions turn out to be less significant than others, the former may be ignored at the discretion of the Society. In the same way, it may be necessary to consider further loading conditions specified by the Society in individual cases.

**7.2.3** The vertical and transverse accelerations are to be calculated as stipulated in [4].

**7.2.4** The impact pressure is to be calculated as stipulated in [6]. For each floor, the K2-factor which appears in the formula for the impact pressure is to be calculated as a function of the area supported by the floor itself.

**7.2.5** In three-dimensional analyses, special attention is to be paid to the distribution of weights and buoyancy and to the dynamic equilibrium of the craft.

In the case of three-dimensional analyses, the longitudinal distribution of impact pressure is to be considered individually, in the opinion of the Society. In general, the impact pressure is to be considered as acting separately on each transverse section of the model, the remaining sections being subject to the hydrostatic pressure.

#### **7.2.6 Loading conditions in still water**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- outer hydrostatic load in still water.

#### **7.2.7 Combined loading condition 1**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- forces of inertia due to the vertical acceleration  $a_v$  of the craft, considered in a downward direction.

#### **7.2.8 Combined loading condition 2**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- forces of inertia due to the vertical acceleration  $a_v$  of the craft, considered in a downward direction,
- impact pressure acting on the bottom of the craft (2 cases):
  - case 1: symmetrically and according to [7.2.5],
  - case 2: asymmetrically and acting on one side of a complete compartment between transverse bulkheads, the other side being subject to hydrostatic load in still water.

#### **7.2.9 Combined loading condition 3**

The following loads are to be considered:

- forces caused by weights which are expected to be carried in the full load condition, distributed according to the weight booklet of the craft,
- forces of inertia due to the transverse acceleration of the craft.

### **7.3 Structural model**

**7.3.1** Primary structures of craft of this type may usually be modelled with beam elements, according to criteria stipulated by the Society. When, however, grounds for the admissibility of this model are lacking, or when the geometry of the structures gives reason to suspect the presence of high stress concentrations, finite element analyses are necessary.

**7.3.2** In general, the extent of the model is to be such as to allow analysis of the behaviour of the main structural elements and their mutual effects.

**7.3.3** In craft dealt with by these Rules, the stiffness of longitudinal primary members (girders and stringers) is, at least outside the machinery space area, generally negligible compared with the stiffness of transverse structures (beams, floors and webs), or their presence may be taken account of by suitable boundary conditions. It is therefore acceptable, in general, to examine primary members in this area of the hull by means of plane analyses of transverse rings.

**7.3.4** In cases where such approximation is not acceptable, the model adopted is to be three-dimensional and is to include the longitudinal primary members.

**7.3.5** When racking behaviour is investigated and loads thus act in the transverse direction (loading condition 3), special attention is to be devoted to modelling of continuous decks and platforms. Such continuous elements, if of sufficient stiffness in the horizontal plane and if sufficiently restrained by the fore- and after-bodies, may withstand transverse deformations of primary rings.

In such cases, taking for granted the provisions above, it is still permissible to examine bidimensional rings, by simulating the presence of decks and platforms with horizontal springs according to criteria specified by the Society.

### **7.4 Boundary conditions**

**7.4.1** Depending upon the loading conditions considered, the following boundary conditions are to be assigned:

- a) Loading condition in still water and combined loading conditions 1 and 2
  - horizontal and transverse restraints, in way of the crossing point of bottom and side shells, if the angle between the two shells is less than approximately 135°,
  - horizontal and transverse restraints, in way of keel, if the bottom/side angle is greater than approximately 135°.

## b) Combined loading condition 3

The vertical and horizontal resultants of the loads, in general other than zero, are to be balanced by introducing two vertical forces and two horizontal forces at the fore and aft ends of the model, distributed on the shells according to the bidimensional flow theory for shear stresses, which are equal and opposite to half the vertical and horizontal resultants of the loads.

**7.4.2** Where a plane model is adopted, the resultants are to be balanced by vertical and horizontal forces, distributed as specified above and acting on the plane of the model itself.

## 7.5 Checking criteria

**7.5.1** For metal structures, the stresses given by the above calculations are to be not greater than the following allowable values, in N/mm<sup>2</sup>:

- bending stress:

$$\sigma_{am} = \frac{150}{K \cdot f'_m \cdot f_s}$$

- shear stress:

$$\tau_{am} = \frac{90}{K \cdot f'_m \cdot f_s}$$

- Von Mises equivalent bending stress:

$$\sigma_{eq, am} = \frac{190}{K \cdot f'_m \cdot f_s}$$

where:

- K : material factor defined in [3]
- $f'_m$  : coefficient depending on the material:
- 1,00 for steel structures
  - 2,15 for aluminium alloy structures
- $f_s$  : safety coefficient, to be assumed:
- 1,00 for combined loading conditions
  - 1,25 for loading condition in still water.

**7.5.2** The compressive values of normal stresses and shear stresses are not to exceed the values of the critical stresses for plates and stiffeners calculated according to [8.5] and [8.6].

**7.5.3** In structural elements also subject to high longitudinal hull girder stresses, allowable and critical stresses are to be reduced, according to criteria specified by the Society.

**7.5.4** For non-metal structures, allowable stresses are to be defined according to criteria specified by the Society.

## 8 Scantlings

### 8.1 Introduction

**8.1.1** This article stipulates requirements for the scantlings of hull structures (plating, stiffeners, primary supporting members). The loads acting on such structures are to be calculated in accordance with the provisions of [6].

**8.1.2** In general, for speed V greater than 45 knots, the scantlings of transverse structures are to be verified also by direct calculations carried out in accordance with [7].

**8.1.3** For all other craft, the Society may, at its discretion and as an alternative to the requirements of this article, accept scantlings for transverse structures of the hull based on direct calculations in accordance with [7].

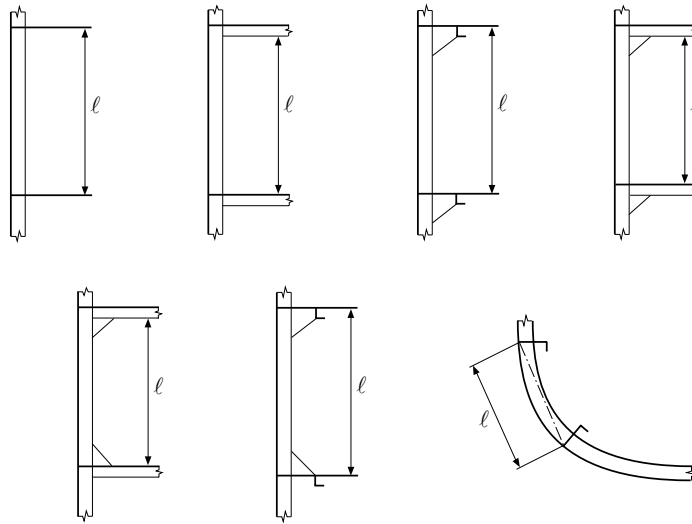
### 8.2 Definitions and symbols

**8.2.1** The definitions and symbols used are the following ones:

rule bracket: a bracket with arms equal to  $\ell/8$ ,  $\ell$  being the span of the connected stiffener. Where the bracket connects two different types of stiffeners (frame and beam, bulkhead web and longitudinal stiffener, etc.) the value of  $\ell$  is to be that of the member with the greater span, or according to criteria specified by the Society,

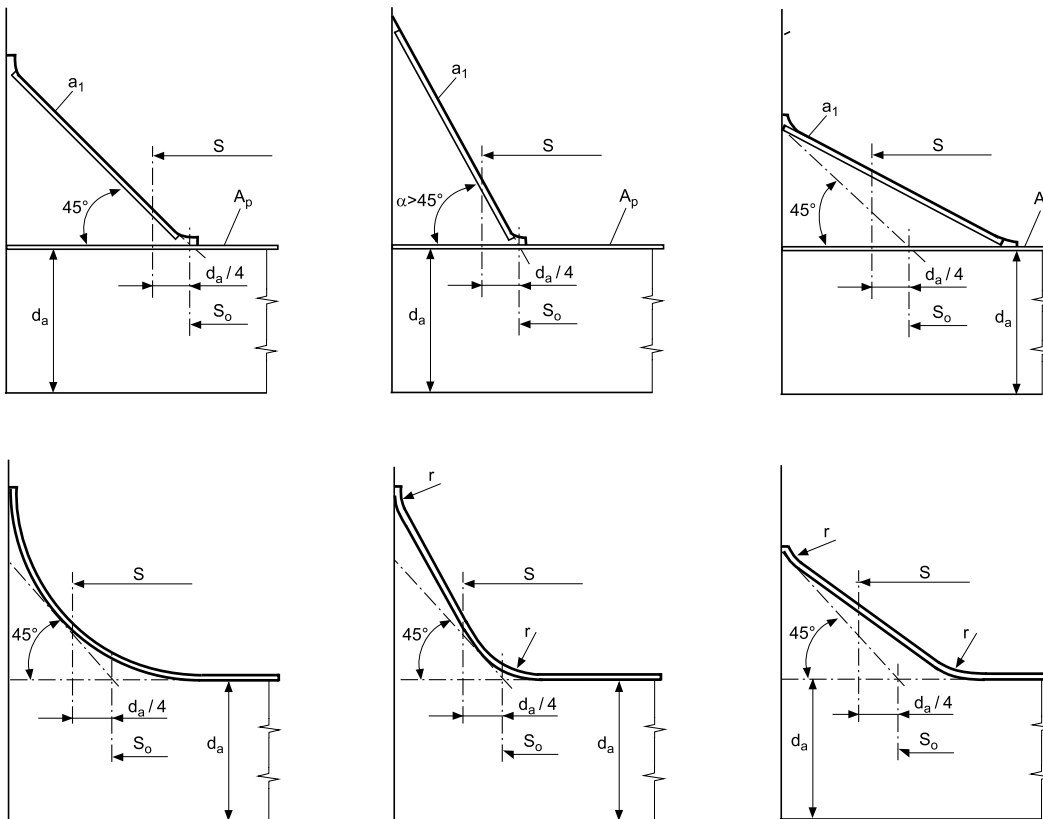
- t : thickness, in mm, of plating and deck panels,
- Z : section modulus, in cm<sup>3</sup>, of stiffeners and primary supporting members,
- s : spacing of stiffeners, in m, measured along the plating,
- $\ell$  : overall span of stiffeners, in m, i.e. the distance between the supporting elements at the ends of the stiffeners (see Fig 4),
- S : conventional scantling span of primary supporting members, in m, to be taken as given in the examples in Fig 5. Special consideration is to be given to conditions different from those shown.
- In no case is S to be less than  $(1,1 S_0)$ ,  $S_0$  being the distance between the internal ends of the conventional brackets as indicated in Fig 5 or, if there are no brackets, between the ends of the members,
- b : actual surface width of the load bearing on primary supporting members; for usual arrangements  $b = 0,5 (l_1 + l_2)$ , where  $l_1$  and  $l_2$  are the spans of stiffeners supported by the primary supporting member,

Figure 4 : Examples of spans of ordinary stiffeners



Note: the connections with end brackets shown in this Figure are relevant to end brackets with Rule dimensions.

Figure 5 : Examples of conventional scantling spans of primary supporting members



$A_p$  = area of girder face plate;  $a_1$  = area of bracket face plate;  $a_1 \geq 0,5 A_p$

$p$  : design pressure, in  $\text{kN/m}^2$ , calculated as defined in [6],

$\sigma_{am}$  : permissible normal stress, in  $\text{N/mm}^2$ ,

$\tau_{am}$  : permissible shear stress, in  $\text{N/mm}^2$ ,

$K$  : material factor defined in [3],

$e$  : ratio between permissible and actual hull girder longitudinal bending stresses (see [8.3])

$$e = \sigma_p / \sigma_{bl}$$

- $\sigma_p$  : maximum permissible stress, in N/mm<sup>2</sup>, as defined in [8.3.4],
- $\sigma_{bl}$  : longitudinal bending stress, in N/mm<sup>2</sup>, as defined in [8.3],
- $\mu$  : defined as follows:

$$\mu = \sqrt{1, 1 - 0, 5 \cdot \left(\frac{s}{l}\right)^2}$$

which needs not be taken greater than 1,0.

### 8.3 Longitudinal strength

**8.3.1** In general, the scantlings resulting from local strength calculations in this article are such as to ensure adequate longitudinal strength of the hull girder for the craft with length less than or equal to 24 m.

**8.3.2** Specific longitudinal strength calculations are required for craft whose hull geometry suggests significant bending moments in still water with the craft at rest.

**8.3.3** For craft with length less than or equal to 65 m, longitudinal strength calculations are, as a rule, to be carried out at the midship section or any other section of the midship area as deemed necessary by the Society.

**8.3.4** Longitudinal stress, in N/mm<sup>2</sup>, in each point of the structures contributing to the craft longitudinal strength is obtained from the following equations:

- at bottom:

$$\sigma_{bl} = \frac{M_{bl}}{W_b} \cdot 10^{-3}$$

- at main deck:

$$\sigma_{bl} = \frac{M_{bl}}{W_d} \cdot 10^{-3}$$

- at height z above the bottom:

$$\sigma_{bl} = M_{bl} \cdot \left( \frac{1}{W_b} - \left( \frac{1}{W_b} + \frac{1}{W_d} \right) \cdot \frac{z}{D} \right) \cdot 10^{-3}$$

where:

- $M_{bl}$  : total bending moment, in kN.m, defined in [5],
- $W_b, W_d$  : section modulus, in m<sup>3</sup>, respectively at bottom and main deck at the stress calculation point of the craft section under consideration. In the section modulus calculation, all the elements contributing to longitudinal strength are to be considered, including long deckhouses, as appropriate.

The values of stress  $\sigma_{bl}$  are not to exceed  $\sigma_p$ , with:

- steel structures:  
 $\sigma_p = 150/K$  (N/mm<sup>2</sup>)
- aluminium alloy structures:  
 $\sigma_p = 70/K$  (N/mm<sup>2</sup>).

**8.3.5** Moreover, the compressive values of  $\sigma$  are not to exceed the values of critical stresses for plates and stiffeners calculated according to [8.5] and [8.6].

## 8.4 Fatigue

### 8.4.1 General

The fatigue strength of structural details is to be checked, when deemed necessary by the Society. In this case, the Society's criteria are to be applied.

### 8.4.2 Effect of stabilisation system

The beneficial effect of stabilisation system may be considered for the purpose of fatigue analysis.

In such a case, loads reductions are to be justified by designer on basis of tank tests or full scale tests.

## 8.5 Buckling strength of steel structural members

### 8.5.1 Application

These requirements apply to steel plates and stiffeners subject to compressive load, to calculate their buckling strength. Other buckling rules can be accepted as agreed with the Society.

### 8.5.2 Elastic buckling stresses of plates

- a) Compressive stress

The elastic buckling stress, in N/mm<sup>2</sup>, is given by:

$$\sigma_E = 0,9 \cdot m_c \cdot E \cdot \left( \frac{t}{1000 \cdot a} \right)^2$$

where:

- $m_c$  : • for plating with stiffeners parallel to compressive stress:

$$m_c = \frac{8,4}{\Psi + 1,1}$$

- for plating with stiffeners perpendicular to compressive stress:

$$m_c = c \cdot \left( 1 + \left( \frac{a}{b} \right)^2 \right) \cdot \frac{2,1}{\Psi + 1,1}$$

- E : Young's modulus, in N/mm<sup>2</sup>, to be taken equal to  $2,06 \cdot 10^5$  N/mm<sup>2</sup> for steel structure,

- t : thickness of plating, in mm,

- a : shorter side of plate, in m,

- b : longer side of plate, in m,

- c : • c = 1,30 when plating is stiffened by floors or deep girders

- c = 1,21 when plating is stiffened by ordinary stiffeners with angle- or T-sections

- c = 1,10 when plating is stiffened by ordinary stiffeners with bulb sections

- c = 1,05 when plating is stiffened by flat bar ordinary stiffeners,

- $\Psi$  : ratio between smallest and largest compressive stresses when the stress presents a linear variation across the panel ( $0 \leq \Psi \leq 1$ ).

- b) Shear stress

The elastic buckling stress is given by:

$$\tau_E = 0,9 \cdot m_t \cdot E \cdot \left( \frac{t}{1000 \cdot a} \right)^2$$

where:

$$m_t = 5,34 + 4 \cdot (a/b)^2$$

E, t, a and b are given in a) above.

**8.5.3 Elastic buckling stress of stiffeners**

a) Column buckling without rotation of the cross section

For the column buckling mode (perpendicular to the plane of plating) the elastic buckling stress, in N/mm<sup>2</sup>, is given by:

$$\sigma_E = 0,001 \cdot E \cdot \frac{I_a}{A \cdot \ell^2}$$

where:

E : Young's modulus, in N/mm<sup>2</sup>, to be taken equal to 2,06 · 10<sup>5</sup> N/mm<sup>2</sup> for steel structures,

I<sub>a</sub> : moment of inertia, in cm<sup>4</sup>, of the stiffener, including plate flange,

A : cross-sectional area, in cm<sup>2</sup>, of the stiffener, including plate flange,

ℓ : span, in m, of the stiffener.

b) Torsional buckling mode

For the torsional mode, the elastic buckling stress, in N/mm<sup>2</sup>, is given by:

$$\sigma_E = \frac{\pi^2 \cdot E \cdot I_w}{10^4 \cdot I_p \cdot \ell^2} \cdot \left( m^2 + \frac{C_k}{m^2} \right) + 0,385 \cdot E \cdot \frac{t}{I_p}$$

where:

E, ℓ : given in a) above,

$$C_k = \frac{C \cdot \ell^4}{\pi^4 \cdot E \cdot I_w} \cdot 10^6$$

m : number of half-waves, given in Tab 9,

I<sub>t</sub> : St. Venant moment of inertia of profile, in cm<sup>4</sup>, without plate flange, equal to:

- for flat bars:

$$I_t = \frac{h_w \cdot t_w^3}{3} \cdot 10^{-4}$$

- for flanged profile:

$$I_t = \frac{1}{3} \cdot \left( h_w \cdot t_w^3 + b_f \cdot t_f^3 \cdot \left( 1 - 0,63 \cdot \frac{t_f}{b_f} \right) \right) \cdot 10^{-4}$$

I<sub>p</sub> : polar moment of inertia of profile, in cm<sup>4</sup>, about connection of stiffener to plate, equal to:

- for flat bars:

$$I_p = \frac{h_w^3 \cdot t_w}{3} \cdot 10^{-4}$$

- for flanged profile:

$$I_p = \left( \frac{h_w^3 \cdot t_w}{3} + h_w^2 \cdot b_f \cdot t_f \right) \cdot 10^{-4}$$

I<sub>w</sub> : sectional moment of inertia of profile, in cm<sup>6</sup>, about connection of stiffener to plate, equal to:

- for flat bars:

$$I_w = \frac{h_w^3 \cdot t_w^3}{36} \cdot 10^{-6}$$

- for T profiles:

$$I_w = \frac{t_f \cdot b_f^3 \cdot h_w^2}{12} \cdot 10^{-6}$$

- for angles and bulb profiles:

$$I_w = \frac{b_f^3 \cdot h_w^2 \cdot 10^{-6}}{12 \cdot (b_f + h_w)^2} \cdot (t_f \cdot (b_f^2 + 2b_f \cdot h_w + 4 \cdot h_w^2) + 3t_w \cdot b_f \cdot h_w)$$

h<sub>w</sub> : web height, in mm,

t<sub>w</sub> : web thickness, in mm,

b<sub>f</sub> : flange width, in mm,

t<sub>f</sub> : flange thickness, in mm; for bulb profiles, the mean thickness of the bulb may be used,

C : spring stiffness factor, exerted by supporting plate panel, equal to:

$$C = \frac{k_p \cdot E \cdot t^3}{3s \cdot \left( 1 + \frac{1,33 \cdot k_p \cdot h_w \cdot t^3}{1000 \cdot s \cdot t_w^3} \right)} \cdot 10^{-3}$$

t : plate thickness, in mm,

s : spacing of stiffeners, in m,

k<sub>p</sub> = 1 - η<sub>p</sub>, not to be less than zero,

η<sub>p</sub> = σ<sub>a</sub> / σ<sub>Ep</sub>

σ<sub>a</sub> : calculated compressive stress in the stiffener,

σ<sub>Ep</sub> : elastic buckling stress of plate as calculated in [8.5.2] a).

c) Web buckling

The elastic buckling stress, in N/mm<sup>2</sup>, is given by:

$$\sigma_E = 3,8 \cdot E \cdot \left( \frac{t_w}{h_w} \right)^2$$

where:

E : given in a) above,

t<sub>w</sub>, h<sub>w</sub> : given in b) above.

**Table 9 : Values of m**

C <sub>k</sub>	m
0 < C <sub>k</sub> < 4	1
4 < C <sub>k</sub> < 36	2
36 < C <sub>k</sub> < 144	3
(m - 1) <sup>2</sup> m <sup>2</sup> < C <sub>k</sub> ≤ m <sup>2</sup> (m + 1) <sup>2</sup>	m

**8.5.4 Critical buckling stresses**

a) Compressive stress

The critical buckling stress in compression σ<sub>c</sub>, in N/mm<sup>2</sup>, for plates and stiffeners, is given by:

$$\sigma_c = \frac{\sigma_E}{SF_1} \quad \text{if } \sigma_E \leq \frac{R_{eH}}{2}$$

$$\sigma_c = \frac{R_{eH}}{SF_1} \cdot \left( 1 - \frac{R_{eH}}{4 \cdot \sigma_E} \right) \quad \text{if } \sigma_E > \frac{R_{eH}}{2}$$

where:

- $R_{eH}$  : minimum yield stress of steel used, in N/mm<sup>2</sup>,  
 $\sigma_E$  : elastic buckling stress calculated according to [8.5.2] a) and [8.5.3].  
 $SF_1$  : safety factor defined in [8.5.4] c).

## b) Shear stress

The critical buckling shear stress  $\tau_c$ , in N/mm<sup>2</sup>, for panels and stiffeners, is given by:

$$\tau_c = \frac{\tau_E}{SF_1} \quad \text{if } \tau_E \leq \frac{\tau_F}{2}$$

$$\tau_c = \frac{\tau_F}{SF_1} \cdot \left(1 - \frac{\tau_E}{4 \cdot \tau_F}\right) \quad \text{if } \tau_E > \frac{\tau_F}{2}$$

where:

$$\tau_F = \frac{R_{eH}}{\sqrt{3}}$$

- $R_{eH}$  : minimum yield stress of steel used, in N/mm<sup>2</sup>,  
 $\tau_E$  : elastic buckling stress calculated according to [8.5.2] b).  
 $SF_1$  : safety factor defined in [8.5.4] c).

## c) Safety factors

The values of safety factor  $SF_1$  to be used are given below:

- Plating
  - local loads:  $SF_1 = 1,00$
  - overall loads:  $SF_1 = 1,00$
- Secondary stiffeners
  - local loads:  $SF_1 = 1,00$
  - overall loads:  $SF_1 = 1,33$
- Primary structure
  - local loads:  $SF_1 = 1,00$
  - overall loads:  $SF_1 = 1,53$

## 8.6 Buckling strength of aluminium alloy structural members

### 8.6.1 Application

These requirements apply to aluminium alloy plates and stiffeners subjected to compressive load, to calculate their buckling strength. Other buckling rules can be accepted as agreed with the Society.

### 8.6.2 Elastic buckling stresses of plates

## a) Compressive stress

The elastic buckling stress, in N/mm<sup>2</sup>, is given by:

$$\sigma_E = 0,9 \cdot m_c \cdot E \cdot \varepsilon \cdot \left(\frac{t}{1000 \cdot a}\right)^2$$

where:

- $m_c$  : • for uniform compression ( $\Psi = 1$ ):  
 $m_c = (1 + \gamma^2)^2$   
 • for compression-bending stress ( $0 \leq \Psi \leq 1$ ):  
 • if  $\gamma < \gamma_1$ :

$$m_c = 1 + \frac{\gamma}{\gamma_1} \cdot (m_1 - 1)$$

- if  $\gamma \geq \gamma_1$ :

$$m_c = \frac{2,1}{1,1 + \Psi} \cdot (1 + \gamma^2)^2$$

- $\gamma$  :  $c/d$ , not to be greater than 1,  
 $c$  : unloaded side of plate, in m,  
 $d$  : loaded side of plate, in m,

$$\gamma_1 = \sqrt{\frac{4 - \frac{1,1 + \Psi}{0,7} - 1}{3}}$$

$$m_1 = \frac{2,1}{1,1 + \Psi} \cdot (1 + \gamma_1^2)^2$$

- $\Psi$  : ratio between smallest and largest compressive stresses when the stress presents a linear variation across the panel ( $0 \leq \Psi \leq 1$ ),

- $E$  : Young's modulus, in N/mm<sup>2</sup>, to be taken equal to  $0,7 \cdot 10^5$  N/mm<sup>2</sup> for aluminium alloy structures,

- $\varepsilon$  : coefficient equal to:

- for edge d stiffened by a flat bar or bulb section:
  - if  $\gamma \geq 1$ :  $\varepsilon = 1,0$
  - if  $\gamma < 1$ :  $\varepsilon = 1,1$
- for edge d stiffened by angle- or T-section:
  - if  $\gamma \geq 1$ :  $\varepsilon = 1,1$
  - if  $\gamma < 1$ :  $\varepsilon = 1,25$

- $t$  : plate thickness, in mm,  
 $a$  : shorter side of plate, in m.

## b) Shear stress

The critical buckling stress, in N/mm<sup>2</sup>, is given by:

$$\tau_E = 0,9 \cdot m_t \cdot E \cdot \left(\frac{t}{1000 \cdot a}\right)^2$$

where:

$E$ ,  $t$  and  $a$  are given in a),

$$m_t = 5,34 + 4 (a / b)^2$$

- $b$  : longer side of plate, in m.

### 8.6.3 Critical buckling stresses

## a) Compressive stress

The critical buckling stress  $\sigma_c$ , in N/mm<sup>2</sup>, is given by:

$$\sigma_c = \frac{\sigma_E}{SF_1} \quad \text{if } \sigma_E \leq \frac{R_{p0,2}}{2}$$

$$\sigma_c = \frac{R_{p0,2}}{SF_1} \cdot \left(1 - \frac{R_{p0,2}}{4 \cdot \sigma_E}\right) \quad \text{if } \sigma_E > \frac{R_{p0,2}}{2}$$

where:

- $R_{p0,2}$  : minimum guaranteed yield stress of aluminium alloy used, in N/mm<sup>2</sup>, in delivery conditions,

- $\sigma_E$  : elastic buckling stress calculated according to [8.6.2] a).

- $SF_1$  : safety factor defined in [8.5.4] c).

b) Shear stress

The critical buckling stress  $\tau_c$ , in N/mm<sup>2</sup>, is given by:

$$\tau_c = \frac{\tau_E}{SF_1} \quad \text{if } \tau_E \leq \frac{R_{p0,2}}{2\sqrt{3}}$$

$$\tau_c = \frac{R_{p0,2}}{SF_1 \cdot \sqrt{3}} \cdot \left(1 - \frac{R_{p0,2}}{4 \cdot \tau_E \cdot \sqrt{3}}\right) \quad \text{if } \tau_E > \frac{R_{p0,2}}{2\sqrt{3}}$$

where:

- $R_{p0,2}$  : as defined in a),
- $\tau_E$  : elastic buckling stress calculated according to b).
- $SF_1$  : safety factor defined in [8.5.4] c).

**8.6.4 Axially loaded stiffeners**

a) Elastic flexural buckling stress

The elastic flexural buckling stress  $\sigma_E$ , in N/mm<sup>2</sup>, is given by:

$$\sigma_E = 69,1 \cdot \left(\frac{r}{1000 \cdot c}\right)^2 \cdot m \cdot 10^4$$

where:

- $r$  : gyration radius, in mm, equal to:
 
$$r = 10 \sqrt{\frac{I}{S + \varphi \cdot t \cdot 10^{-2}}}$$
- $I$  : moment of inertia of the stiffener, in cm<sup>4</sup>, calculated with a plate flange of width equal to  $\varphi$ ,
- $\varphi$  : smaller of:
  - 800 a, and
  - 200 c
- $S$  : area of the cross section of the stiffener, in cm<sup>2</sup>, excluding attached plating,
- $m$  : coefficient depending on boundary conditions:
  - $m = 1$  for a stiffener simply supported at both ends,
  - $m = 2$  for a stiffener simply supported at one end and fixed at the other one,
  - $m = 4$  for a stiffener fixed at both ends.

b) Local elastic buckling stresses

The local elastic buckling stresses  $\sigma_E$ , in N/mm<sup>2</sup>, are given by:

- for flat bars:

$$\sigma_E = 55 \cdot \left(\frac{t_w}{h_w}\right)^2 \cdot 10^3$$

- for built up stiffeners with symmetrical flange:

- web:

$$\sigma_E = 27 \cdot \left(\frac{t_w}{h_w}\right)^2 \cdot 10^4$$

- flange:

$$\sigma_E = 11 \cdot \left(\frac{t_f}{b_f}\right)^2 \cdot 10^4$$

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.

c) Critical buckling stress

The critical buckling stress  $\sigma_c$ , in N/mm<sup>2</sup>, is given by:

$$\sigma_c = \frac{\sigma_E}{SF_1} \quad \text{if } \sigma_E \leq \frac{R_{p0,2}'}{2}$$

$$\sigma_c = \frac{R_{p0,2}'}{SF_1} \cdot \left(1 - \frac{R_{p0,2}'}{4 \cdot \sigma_E}\right) \quad \text{if } \sigma_E > \frac{R_{p0,2}'}{2}$$

where:

- $R_{p0,2}'$  : minimum as-welded guaranteed yield stress of aluminium alloy used, in N/mm<sup>2</sup>,
- $\sigma_E$  : either overall elastic buckling stress or local elastic buckling stress calculated according to a) or b), whichever is the less.
- $SF_1$  : safety factor defined in [8.5.4] c).

**8.7 Plating**

**8.7.1 General**

The thickness of plating is not to be less than the thicknesses calculated according to [8.7.2] and [8.7.3].

**8.7.2 Plating subjected to lateral pressure**

The thickness, in mm, required for the purposes of resistance to design pressure, is given by the formula:

$$t = 22,4 \cdot \mu \cdot s \cdot \sqrt{\frac{p}{\sigma_{am}}}$$

Pressure  $p$ , in kN/m<sup>2</sup>, and permissible stress  $\sigma_{am}$ , in N/mm<sup>2</sup>, are defined in requirements stipulated in [8.7.4] to [8.7.9] for the various parts of the hull.

**8.7.3 Minimum thicknesses**

In addition with [8.7.2], the thicknesses of plating are to be not less than the minimum values given in Tab 10, in general.

Lesser thicknesses than the one given in Tab 10 may be accepted provided that their adequacy in relation to strength against buckling and collapse is demonstrated to the satisfaction of the Society. Adequate provision is also to be made to limit corrosion.

**Table 10 : Minimum thicknesses**

Element	Minimum thickness (mm)
Shell plating:	
• Bottom shell plating	$1,35 \cdot L^{1/3} \geq 2,5$
• Side shell plating and wet deck plating	$1,15 \cdot L^{1/3} \geq 2,5$
Deck plating	2,5
Bulkhead plating	2,5
Deckhouse side shell plating	2,5

### 8.7.4 Keel

The thickness of keel plating is to be not less than that required for adjacent bottom plating.

This requirement may be waived in the case of special arrangements for dry-docking of craft of unusual hull design in the opinion of the Society.

### 8.7.5 Bottom shell and bilge

a) The formula given in [8.7.2] is to be applied for the following two conditions:

1)  $p$  : impact pressure  $p_{si}$  if occurring on the bottom as defined in [6.3];

$\sigma_{am}$  : • steel structures:

$$\sigma_{am} = 235/K \text{ (N/mm}^2\text{)}$$

• aluminium alloy structures:

$$\sigma_{am} = 95/K \text{ (N/mm}^2\text{)},$$

2)  $p$  : sea pressure  $p_s$  as defined in [6.4];

$\sigma_{am}$  : • steel structures:

$$\sigma_{am} = 185/K \text{ (N/mm}^2\text{)}$$

• aluminium alloy structures:

$$\sigma_{am} = 85/K \text{ (N/mm}^2\text{)}.$$

b) The thickness of bilge plating is not, in any case, to be less than that of the bottom and side adjacent, whichever is greater.

c) The thickness of plates connected to the stern frame, or in way of propeller shaft brackets, is to be at least 1,5 times the thickness of the adjacent plating.

d) In craft fitted with a bow thruster, the thickness of the connection with the housing of such propeller is to be considered individually by the Society.

### 8.7.6 Sea intakes and other openings

a) Sea intakes and other openings are to be well rounded at the corners and located, as far as practicable, well clear of sharp edges.

b) Sea chests are to have scantlings as for watertight tank bulkheads (see [8.11]), taking a design pressure  $p_t$  in  $\text{kN/m}^2$ , equal to:

$$p_t = p_s + 0,5 \cdot p_{si}$$

where  $p_s$  and  $p_{si}$  are as defined in [6.4] and [6.3] respectively.

### 8.7.7 Plating of side shell and front walls

a) The formula given in [8.7.2] is to be applied, assuming:

$p$  : • sea pressure  $p_s$  as defined in [6.4], for side shell plating,

• sea pressure  $p_{sf}$  as defined in [6.5], for front wall plating,

$\sigma_{am}$  : • steel structures:

$$\sigma_{am} = 185/K \text{ (N/mm}^2\text{)}$$

• aluminium alloy structures:

$$\sigma_{am} = 85/K \text{ (N/mm}^2\text{)}.$$

If front walls are located at the fore end of the hull, the pressure  $p_{sf}$  (see [6.5]) and the allowable stresses are to be considered individually by the Society.

b) The thickness of the sheerstrake is to be not less than that of the side or stringer plate.

c) At the ends of deckhouses, the thickness of the sheerstrake is to be suitably increased.

d) Where side scuttles or windows or other openings are located on the sheerstrake, the thickness is to be increased to compensate for the openings.

### 8.7.8 Deck plating

a) The formula given in [8.7.2] is to be applied, assuming:

$p$  : deck pressure  $p_d$  as defined in [6.7];

$\sigma_{am}$  : • steel structures:

$$\sigma_{am} = 185/K \text{ (N/mm}^2\text{)}$$

• aluminium alloy structures:

$$\sigma_{am} = 85/K \text{ (N/mm}^2\text{)}.$$

b) The thickness, in mm, of decks intended for the carriage of vehicles is to be not less than the value calculated by the formula:

$$t = f \cdot (c \cdot P \cdot K)^{0,5}$$

where:

$f$  : coefficient equal to:

- 3,9 for steel structures
- 5,6 for aluminium alloy structures,

$c$  : coefficient given in Tab 11 as a function of the dimensions  $u$  and  $v$  of the tyre print (see Fig 6),

$P$  : static load on the tyre print, in kN, increased by  $(1 + 0,4 \cdot a_v)$ ,  $a_v$  being the design vertical acceleration defined in [4.1].

Where there are double wheels, the tyre print consists of both.

c) The designer is to supply details of tyre pressure, wheel dimensions, loads on wheels and tyre print dimensions. Where this information is not available, an approximate value of the thickness, in mm, may be obtained from the following formula:

$$t = f_1 \cdot C_1 \cdot (P_1 \cdot K)^{0,5}$$

where:

$f_1$  : coefficient equal to:

- 0,28 for steel structures
- 0,38 for aluminium alloy structures,

$C_1$  : coefficient equal to:

- 3,60 for vehicles with 4 wheels per axle
- 4,45 for vehicles with 2 wheels per axle,

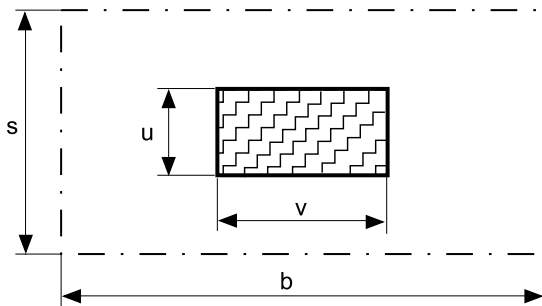
$P_1$  : static axle load, in kN, increased by  $(1 + 0,4 \cdot a_v)$ ,  $a_v$  being the design vertical acceleration defined in [4.1].

d) The thickness of areas of watertight decks or flats forming steps in watertight bulkheads or the top or the bottom of a tank is also to comply with the provisions of [8.11].

Table 11 : Coefficient c

b/s	v/u	u/s									
		0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
1	0,5	0,242	0,174	0,138	0,113	0,094	0,080	0,077	0,060	0,052	0,045
	1,0	0,222	0,160	0,122	0,099	0,079	0,066	0,055	0,045	0,037	0,030
	2,0	0,198	0,134	0,098	0,073	0,053	–	–	–	–	–
	3,0	0,175	–	–	–	–	–	–	–	–	–
1,4	0,5	0,228	0,189	0,158	0,128	0,111	0,096	0,083	0,073	0,064	0,056
	1,0	0,217	0,177	0,143	0,116	0,098	0,082	0,070	0,060	0,051	0,043
	2,0	0,196	0,153	0,119	0,092	0,072	0,058	0,046	–	–	–
	3,0	0,178	0,134	0,100	0,072	–	–	–	–	–	–
≥ 2,5	0,5	0,232	0,196	0,163	0,135	0,117	0,100	0,087	0,077	0,067	0,059
	1,0	0,219	0,184	0,150	0,123	0,105	0,088	0,076	0,066	0,056	0,048
	2,0	0,199	0,161	0,129	0,101	0,082	0,067	0,055	0,046	0,037	0,031
	3,0	0,185	0,142	0,108	0,083	0,064	0,051	0,038	0,028	0,019	0,012

Figure 6 : Tyre print



8.7.9 Plating of deckhouse walls

- a) The formula given in [8.7.2] assuming:
  - p : sea pressure  $p_{su}$  as defined in [6.6];
  - $\sigma_{am}$  :
    - steel structures:  $\sigma_{am} = 185/K$  (N/mm<sup>2</sup>)
    - aluminium alloy structures:  $\sigma_{am} = 85/K$  (N/mm<sup>2</sup>).
- b) Openings (doors, windows) are to be well rounded at the corners.
- c) Where there is no access from inside deckhouses to 'tween-decks below or where one of the boundary walls concerned is in a particularly sheltered position, reduced scantlings compared with those above may be accepted, at the discretion of the Society.
- d) For unprotected front walls located at the fore end, the pressure  $p_{su}$  and allowable stresses are to be considered individually by the Society.

8.8 Ordinary stiffeners

8.8.1 General

This article states the requirements to be complied with for ordinary stiffeners of the bottom, sides, decks and, for catamaran, the cross-deck and internal sides.

The Section modulus, shear area, and web thickness are not to be less than values calculated according to [8.8.2], [8.8.3] and [8.8.4].

The ends of ordinary stiffeners are, in general, to be connected by means of rule brackets to effective supporting structures.

Ends without brackets are accepted at the penetrations of primary supporting members or bulkheads by continuous stiffeners, provided that there is sufficient effective welding section between the two elements. Where this condition does not occur, bars may be accepted instead of the brackets, at the discretion of the Society.

8.8.2 Stiffeners submitted to lateral pressure

The Section modulus  $Z$ , in cm<sup>3</sup>, and the shear area  $A_t$ , in cm<sup>2</sup>, required for the purpose of supporting the design pressure transmitted by the plating, area given by the following formulae:

$$Z = 1000 \cdot \frac{\ell^2 \cdot s \cdot p}{m \cdot \sigma_{am}}$$

$$A_t = 5 \cdot \frac{\ell \cdot s \cdot p}{\tau_{am}}$$

Table 12 : Coefficient m

Type of stiffener	m
Continuous longitudinal stiffeners without Rule brackets at the ends of span	12
Longitudinal and transverse stiffeners ith Rule brackets at the ends of span	19
Longitudinal and transverse stiffeners with Rule brackets at one end of span	15
Non-continuous longitudinal stiffeners and transverse stiffeners without Rule brackets at the ends of span	8

where  $m$  is a coefficient depending on the type of stiffener and on whether there are Rule brackets at the end of each individual span. The values of  $m$  are indicated in Tab 13.

The pressure  $p$ , in  $\text{kN/mm}^2$ , and allowable stresses  $\sigma_{am}$  and  $\tau_{am}$ , in  $\text{N/mm}^2$ , are defined in [8.8.5] to [8.8.8] for the various regions of the hull.

These formulae are valid for stiffeners whose web is perpendicular to the plating, or form an angle to the plating of less than  $15^\circ$ .

In the case of stiffeners whose web form an angle  $\alpha$  greater than  $15^\circ$  to the perpendicular to the plating, the required modulus and shear area may be obtained from the same formulae, dividing the values of  $Z$  and  $A_t$  by  $\cos(\alpha)$ .

The Section modulus of ordinary stiffeners is to be calculated in association with an effective width of plating equal to the spacing of the stiffeners, without exceeding 20 per cent of the span.

### 8.8.3 Minimum thicknesses

- a) For steel stiffeners, the web thickness is to be not less than:
- 1/18 of the depth, for flat bars,
  - 1/50 of the depth, for other sections,
- and the thickness of the face plate is to be not less than 1/15 of its width.
- b) For aluminium alloy stiffeners, the web thickness is to be not less than:
- 1/15 of the depth, for flat bars,
  - 1/35 of the depth, for other sections,
- and the thickness of the face plate is to be not less than 1/20 of its width.

### 8.8.4 Connection to primary members

- a) In general, the resistant weld section  $A_w$ , in  $\text{cm}^2$ , connecting the ordinary stiffeners to the web of primary members, is not to be less than:

$$A_w = \phi \cdot p \cdot s \cdot \ell \cdot K \cdot 10^{-3}$$

where:

- $\phi$  : coefficient as indicated in Tab 13
- $p$  : design pressure, in  $\text{kN/m}^2$ , acting on the secondary stiffeners, defined below for various hull regions,
- $s$  : spacing of ordinary stiffeners, in  $\text{m}$ ,
- $\ell$  : span of ordinary stiffeners, in  $\text{m}$ ,
- $K$  : greatest material factor of ordinary stiffener and primary member, defined in [3].

- b) For aluminium alloys, when calculating the resistant connecting weld section, the fillet weld length  $d_e$ , in  $\text{mm}$ , is determined as follows (see cases 1 and 2 in Tab 13):
- case 1:  $d_e = d - 20$   
where  $d$  is the length of the weld, in  $\text{mm}$ ,
  - case 2: for extruded T stiffeners, the lesser of:  
 $d_e = b - 20$  and  $d_e = 4t$ ,  
where  $b$ , in  $\text{mm}$ , is the flange width of the extruded stiffener and  $t$ , in  $\text{mm}$ , is the web thickness of the extruded stiffener.

**Table 13 : Coefficient  $\phi$**

Case	Weld	Aluminium alloy	Steel
1	Parallel to the reaction exerted on primary member	200	100
2	Perpendicular to the reaction exerted on primary member	160	75

### 8.8.5 Bottom and bilge

- a) The formulas given in [8.8.2] and [8.8.4] are to be applied for the following two conditions:

#### 1) Impact

$p$  : impact pressure  $p_{si}$  if occurring on the bottom as defined in [6.3];

- $\sigma_{am}, \tau_{am}$  :
- steel structures:  
 $\sigma_{am} = 150/K$  ( $\text{N/mm}^2$ )  
 $\tau_{am} = 90/K$  ( $\text{N/mm}^2$ )
  - aluminium alloy structures:  
 $\sigma_{am} = 70/K$  ( $\text{N/mm}^2$ )  
 $\tau_{am} = 45/K$  ( $\text{N/mm}^2$ ),

#### 2) Sea pressure

$p$  : sea pressure  $p_s$  as defined in [6.4];

- $\sigma_{am}, \tau_{am}$  :
- stiffeners contributing to the longitudinal strength:
    - steel structures:  
 $\sigma_{am} = 150 C_s/K$  ( $\text{N/mm}^2$ )  
 $\tau_{am} = 90/K$  ( $\text{N/mm}^2$ )
    - aluminium alloy structures:  
 $\sigma_{am} = 70 C_A/K$  ( $\text{N/mm}^2$ )  
 $\tau_{am} = 45/K$  ( $\text{N/mm}^2$ ),
  - stiffeners not contributing to the longitudinal strength:
    - steel structures:  
 $\sigma_{am} = 150/K$  ( $\text{N/mm}^2$ )  
 $\tau_{am} = 90/K$  ( $\text{N/mm}^2$ )
    - aluminium alloy structures:  
 $\sigma_{am} = 70/K$  ( $\text{N/mm}^2$ )  
 $\tau_{am} = 45/K$  ( $\text{N/mm}^2$ ),

where  $C_s$  and  $C_A$  are given by Tab 14.

- b) Both single and double bottoms are generally to be longitudinally framed.
- c) Bottom longitudinals are preferably continuous through the transverse elements. Where they are interrupted at a transverse watertight bulkhead, continuous brackets are to be positioned through the bulkhead so as to connect the ends of longitudinals.

### 8.8.6 Side and front wall

- a) The formulas given in [8.8.2] and [8.8.4] are to be applied, assuming:

- p : • sea pressure  $p_s$  as defined in [6.4], for side stiffeners,  
 • sea pressure  $p_{sf}$  as defined in [6.5], for front wall stiffeners,
- $\sigma_{am}, \tau_{am}$  : • side stiffeners contributing to the longitudinal strength:  
 • steel structures:  
 $\sigma_{am} = 150 C_s/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)  
 • aluminium alloy structures:  
 $\sigma_{am} = 70 C_A/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),  
 • side stiffeners not contributing to the longitudinal strength and front wall stiffeners:  
 • steel structures:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)  
 • aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

where  $C_s$  and  $C_A$  are given by Tab 14.

- b) For unprotected front walls located at the fore end, the pressure  $p_{sf}$  (see [6.5]) and allowable stresses are to be considered individually by the Society.

**8.8.7 Deck**

- a) Formulas given in [8.8.2] and [8.8.4] are to be applied, assuming:  
 p : deck pressure  $p_d$  as defined in [6.7],  
 $\sigma_{am}, \tau_{am}$  : • stiffeners contributing to the longitudinal strength:  
 • steel structures:  
 $\sigma_{am} = 150 C_s/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)

- aluminium alloy structures:  
 $\sigma_{am} = 70 C_A/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),
- stiffeners not contributing to the longitudinal strength:  
 • steel structures:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)  
 • aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

where  $C_s$  and  $C_A$  are given by Tab 14.

- b) Where there are concentrated loads of significant magnitude, deck stiffeners are to be adequately strengthened. In particular, stiffeners of decks intended for the carriage of vehicles are to be able to support the concentrated loads transmitted by the wheels, including inertia effects.

In this case, the structural check is, in general, to be carried out adopting the static model of the continuous girder on several supports (formed by primary supporting members) and considering the most severe vehicle loading arrangement for deck stiffeners. The normal and shear stresses thus calculated are not to exceed the allowable limits defined above.

- c) The ordinary stiffeners of decks or flats constituting the top or bottom of tanks are also to comply with the requirements of [8.11].
- d) Where longitudinals are interrupted in way of watertight bulkheads or reinforced transverse structures, the continuity of the structure is to be maintained by means of brackets penetrating the transverse element. The Society may allow double brackets welded to the transverse element, provided that special provision is made for the alignment of longitudinals, and full penetration welding is used.

**Table 14 : Coefficients  $C_s$  and  $C_A$**

L	x/L	Steel structures $C_s$	Aluminium alloy structures $C_A$
$L \leq 24$ m	$0 \leq x/L \leq 1$	1	1
$L > 24$ m (Note 2)	$0 \leq x/L \leq 1$	$1,4 - 1/e$	$1,3 - 1/e$
Alternative method for 24 m < $L \leq 65$ m (Note 3)	$x/L < 0,1$	1	1
	$0,1 \leq x/L \leq 0,3$	$1 + 0,5 \cdot \left(0,4 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 1\right)$	$1 + 0,5 \cdot \left(0,3 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 1\right)$
	$0,3 < x/L < 0,7$	$1,4 - \frac{1}{e}$	$1,3 - \frac{1}{e}$
	$0,7 \leq x/L \leq 0,9$	$1 - 0,5 \cdot \left(0,4 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 9\right)$	$1 - 0,5 \cdot \left(0,3 - \frac{1}{e}\right) \cdot \left(10 \cdot \frac{x}{L} - 9\right)$
	$0,9 < x/L \leq 1$	1	1

**Note 1:** In these formulae, the values of  $C_s$  and  $C_A$  are to be taken less than or equal to 1.  
**Note 2:** The ratio e is to be calculated at the location x, on basis of bending moment distribution defined in [4.1] and [4.2].  
**Note 3:** The ratio e is to be calculated at the section comprised between  $0,3 \cdot L$  and  $0,7 \cdot L$  at which e takes the highest value.

### 8.8.8 Boundary walls of deckhouses

- a) Formulas given in [8.8.2] and [8.8.4] are to be applied, assuming:
- $p$  : sea pressure  $p_{su}$  as defined in [6.6],
- $\sigma_{am}, \tau_{am}$  :
- steel structures:
    - $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),
  - aluminium alloy structures:
    - $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>).
- b) If unprotected front walls are located at the fore end, the pressure  $p_{su}$  and the allowable stresses are to be considered individually by the Society.
- c) Any front or side wall vertical stiffeners of first tier deckhouses are to be connected, by means of brackets at the ends, to strengthening structures for decks or adjacent sides.
- d) Longitudinal stiffeners are to be fitted on the upper and lower edges of large openings in the plating. The openings for doors are, in general, to be stiffened all the way round.
- e) Where there is no access from inside deckhouses to 'tween-decks below, or where a deckhouse boundary wall is in a particularly sheltered location, reduced scantlings with respect to those stipulated above may be accepted, in the opinion of the Society.

## 8.9 Primary supporting members

### 8.9.1 General

This article gives the requirements to be complied with for primary supporting members of the bottom, sides and decks.

The primary supporting members (floors, frames, beams) are to form continuous transverse frames. In general, the stiffened frame spacing, in mm, is not to exceed:

$$1200 + 10 L$$

without being greater than 2 m.

Primary supporting members with spacing other than that defined above may be required for specific parts of the hull (e.g. machinery space, under pillars), as stipulated in the provisions below.

The section modulus, shear area and thicknesses where relevant, are to be not less than values calculated according to [8.9.2] and [8.9.3].

Particular attention is to be paid to compressive buckling strength of associated plating of transverse primary members

### 8.9.2 Primary members submitted to lateral pressure

The section modulus  $Z$ , in cm<sup>3</sup>, and shear area  $A_t$ , in cm<sup>2</sup>, required to support the design pressure transmitted by the ordinary stiffeners are given by the following formulae:

$$Z = 1000 \cdot \frac{S^2 \cdot b \cdot p}{m \cdot \sigma_{am}}$$

$$A_t = 5 \cdot \frac{S \cdot b \cdot p}{\tau_{am}}$$

where:

- $m$  : coefficient which depends on support conditions at the ends of the girder span, generally assumed to be equal to:
- 10 for floors, bottom girders, side frames, deck beams and girders, vertical webs of superstructures
  - 12 for side stringers.

In special circumstances, a different value may be taken for  $m$ , at the discretion of the Society.

The pressure  $p$ , in kN/m<sup>2</sup>, and allowable stresses  $\sigma_{am}$  and  $\tau_{am}$ , in N/mm<sup>2</sup>, are defined in [8.9.4] to [8.9.7] for various parts of the hull.

The above formulae are applicable where reinforced structures are not of the grillage type. Otherwise, the scantlings of reinforced structures are to be stipulated by means of direct calculations performed on the basis of criteria agreed upon with the Society.

The section modulus of primary supporting members is to be calculated in association with an attached plating, according to criteria specified by the Society.

In case of primary structure made of floating frames and extruded panels, the flexural contribution of the extruded plating may generally be disregarded.

### 8.9.3 Minimum thicknesses

- a) For steel stiffeners, the following geometric ratios are to be satisfied:
- the web thickness is to be not less than 1/80 of web depth,
  - the face plate thickness is to be not less than 1/30 of face plate breadth (1/15 for face plates which are not symmetrical with respect to the web).
- b) For aluminium stiffeners, the following geometric ratios are to be satisfied, where the compressive stress is not known:
- the web thickness is to be not less than 1/35 of web depth,
  - the face plate thickness is to be not less than 1/20 of face plate breadth (1/10 for face plates which are not symmetrical with respect to the web).

### 8.9.4 Floors and girders of single bottom

The formula given in [8.9.2] are to be applied.

- a) The section modulus and shear area are given by the following two conditions:

#### 1) Impact

$p$  : impact pressure  $p_{si}$  if occurring on the bottom as defined in [6.3];

- $\sigma_{am}, \tau_{am}$  :
- steel structures:
    - $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
  - aluminium alloy structures:
    - $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

2) Sea pressure

$p$  : sea pressure  $p_s$  as defined in [6.4];

- $\sigma_{am}, \tau_{am}$  :
- steel floors:
    - $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
  - aluminium alloy floors:
    - $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>)
  - steel girders:
    - $\sigma_{am} = 150 C_s/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>)
  - aluminium alloy girders:
    - $\sigma_{am} = 70 C_A/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

where  $C_s$  and  $C_A$  are given by Tab 14.

- b) Floors are to be positioned in way of side and deck transverses. Intermediate floors may also be fitted provided that they are adequately connected at the ends.
- c) Manholes and other openings are not to be located at the ends of floor or girder spans, unless shear stress checks are carried out in such areas.
- d) Floors are to be fitted in machinery spaces, generally at every frame, and additional stiffeners are to be provided at bottom in way of machinery and pillars.
- e) In way of main machinery seatings, girders are to be positioned extending from the bottom to the foundation plate of main engines.
- f) A girder is, generally, to be fitted centreline for dry-docking. The height of such a girder is to be not less than that of floors amidships and the thickness less than the value  $t$ , in mm, obtained from the formula:

- for steel:

$$t = (0,05 \cdot L + 2) \cdot K^{0,5}$$

- for aluminium alloys:

$$t = (0,07 \cdot L + 2,5) \cdot K^{0,5}$$

The girder is to be fitted with a continuous face plate above the floors, its area not less than the value  $A_p$ , in cm<sup>2</sup>, given by the formula:

- for steel:

$$A_p = 0,25 \cdot L \cdot K$$

- for aluminium alloys:

$$A_p = 0,50 \cdot L \cdot K$$

In hulls with a longitudinally framed bottom and width  $B > 8$  m, side girders are also to be positioned in such a way as to divide the floor span into approximately equal parts. The thickness of the web may be assumed to be equal to that of the centre girder less 1 mm, and the area of the face plate may be reduced to 60% of that of the centre girder. Where side girders are intended to support floors, a structural check of their scantlings is to be carried out as deemed necessary by the Society.

**8.9.5 Sides and front walls**

- a) Formulas given in [8.9.2] are to applied, assuming:

- $p$  :
- sea pressure  $p_s$  as defined in [6.4] for primary members of sides,
  - sea pressure  $p_{sf}$  as defined in [6.5] for primary members of front walls,

- $\sigma_{am}, \tau_{am}$  :
- steel structures:
    - $\sigma_{am} = 150/K - \sigma_a$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),
  - aluminium alloy structures:
    - $\sigma_{am} = 70/K - \sigma_a$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

$\sigma_a$  being the stress induced by the normal force in side transverses due to deck loads transmitted by deck beams.

- b) For unprotected front walls located at the fore end, the pressure  $p_{sf}$  (see [6.5]) and allowable stresses are to be considered individually by the Society.

**8.9.6 Decks**

- a) In the absence of concentrated loads transmitted to the primary supporting member by pillars or other primary supporting members, the formula given in [8.9.2] are to be applied for deck transverses and deck girders supporting longitudinals and beams, respectively assuming:

$p$  : deck pressure  $p_d$  as defined in [6.7],

- $\sigma_{am}, \tau_{am}$  :
- steel deck transverses:
    - $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),
  - aluminium alloy deck transverses:
    - $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),
  - steel deck girders:
    - $\sigma_{am} = 150 C_s/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),
  - aluminium alloy deck girders:
    - $\sigma_{am} = 70 C_A/K$  (N/mm<sup>2</sup>)
    - $\tau_{am} = 45/K$  (N/mm<sup>2</sup>),

where  $C_s$  and  $C_A$  are given by Tab 14.

- b) The primary members of decks or flats constituting the top or bottom of tanks are also to comply with the requirements of [8.11].
- c) When there are concentrated loads of significant magnitude (e.g. transmitted by pillars or other primary members or due to the carriage of vehicles), deck girders are to be adequately strengthened.

In this case the structural check is, generally, to be carried out by using the static model of a beam with partial clamping at its ends (clamping coefficient = 0,30).

The allowable stresses stipulated above are to be considered.

The beam section is to be kept constant over its length.

- d) At the discretion of the Society, calculations based on different static models may be accepted, depending on the structural typology adopted.

### 8.9.7 Deckhouse boundary walls

a) The formulas given in [8.9.2] are to be applied, assuming:

$p$  : sea pressure  $p_{su}$  as defined in [6.6],

$\sigma_{am}, \tau_{am}$  : • steel structures:

$$\sigma_{am} = 150/K \text{ (N/mm}^2\text{)}$$

$$\tau_{am} = 90/K \text{ (N/mm}^2\text{)},$$

• aluminium alloy structures:

$$\sigma_{am} = 70/K \text{ (N/mm}^2\text{)}$$

$$\tau_{am} = 45/K \text{ (N/mm}^2\text{)}.$$

b) Where there is no access from inside deckhouses to 'tween-decks below or where a deckhouse boundary wall is in a particularly sheltered location, reduced scantlings with respect to those stipulated above may be accepted at the discretion of the Society.

c) For unprotected front walls located at the fore end, the pressure  $p_{su}$  and allowable stresses are to be considered individually by the Society.

## 8.10 Pillars

### 8.10.1 Steel pillars

The minimum area  $A$ , in  $\text{cm}^2$ , of the section of a pillar, is to be not less than:

• for  $0 \leq \lambda \leq 1,5$

$$A = \frac{Q \cdot (1 + 0,75 \cdot \lambda^2)}{12}$$

• for  $\lambda > 1,5$

$$A = \frac{Q \cdot \lambda^2}{10}$$

where:

$\lambda$  : slenderness of the pillar, i.e. the ratio between the pillar length, in m, and the minimum radius of gyration of the pillar cross-section, in cm,

$Q$  : load acting on the pillar, in kN, equal to:

$$Q = A_{PG} \cdot p + Q_C$$

$A_{PG}$  : area of the deck acting on the pillar, in  $\text{m}^2$ ,

$p$  : deck load as defined in [6.7],

$Q_C$  : load from pillars above, if any, or any other concentrated load acting on the pillar, in kN.

The formula for the calculation of  $A$  applies in the case of solid, tubular or prismatic pillars of normal steel. Where higher tensile steel is used, the minimum area may be determined as follows:

$$A' = A \cdot (235/R_{eH}) \text{ provided } \lambda \leq 1$$

where:

$R_{eH}$  : yield stress, in  $\text{N/mm}^2$ , of the steel considered.

Where possible, each pillar is to be aligned with another pillar above or below. Stiffeners ensuring efficient load distribution are to be fitted at the ends of pillars. Where, in exceptional circumstances, pillars support eccentric loads, the scantlings are to be adequately increased to withstand the bending moment due to the eccentricity of the load.

Where pillars on the inner bottom are not in way of inter-sections of floors and girders, partial floors or other structures are to be provided to support the load transmitted.

In general, solid or open-section pillars are to be fitted in tanks; this is compulsory for pillars located in spaces intended for products which may produce explosive gases.

Heads and heels of pillars are to be continuously welded. The welded connections of stiffeners directly involved in the arrangement of pillars are to be adequately stiffened where necessary.

The thickness of tubular or closed-section pillars is generally to be not less than 1/35 of the nominal diameter or greater dimension of the section. In no case is this thickness to be less than 3mm.

The thickness of face plates of built-up pillars is to be not less than 1/18 of the unsupported span of the face plate.

### 8.10.2 Pillars made of aluminium alloys

a) Loads on pillars

Where pillars are aligned, the compressive load  $Q$ , in kN, is equal to the sum of loads supported by the pillar considered and those supported by the pillars located above, multiplied by a weighting factor.

The weighting factor depends on the relative position of each pillar with respect to that considered.

This coefficient is equal to:

- 1,0 for the pillar considered,
- 0,9 for the pillar immediately above (first pillar of the line),
- $0,81 = 0,9^2$  for the following pillar (second pillar of the line),
- $0,729 = 0,9^3$  for the third pillar of the line,
- in general,  $0,9^n$  for the  $n^{\text{th}}$  pillar of the line, but not less than  $0,9^7 = 0,478$ .

b) Critical stress for overall buckling of pillars

For global buckling behaviour of pillars made of aluminium alloy, the critical stress,  $\sigma_c$ , in  $\text{N/mm}^2$ , is given by the formula:

$$\sigma_c = \frac{R_{p0,2}'}{0,85 + 0,25 \cdot \left(\frac{f \cdot \ell}{r}\right)} \cdot C$$

where:

$R_{p0,2}'$  : minimum as-welded guaranteed yield stress of aluminium alloy used, in  $\text{N/mm}^2$ ,

$C$  : coefficient as given in Fig 7, and equal to:

- for alloys without heat treatment:

$$\frac{1}{1 + \lambda + \sqrt{(1 + \lambda)^2 - (0,68 \cdot \lambda)}}$$

- for alloys with heat treatment:

$$\frac{1}{1 + \lambda + \sqrt{(1 + \lambda)^2 - (3,2 \cdot \lambda)}}$$

$$\lambda = \frac{R_{p0,2}'}{\sigma_E}$$

$$\sigma_E = \frac{69,1}{\left(\frac{f \cdot \ell}{r}\right)^2}$$

- $\ell$  : length of pillar, in m,
- $r$  : minimum radius of gyration, in cm, of the pillar cross section, equal to:

$$r = \sqrt{\frac{I}{A}}$$

- $I$  : minimum moment of inertia, in cm<sup>4</sup>, of the pillar cross section,
- $A$  : area, in cm<sup>2</sup>, of the pillar cross section,
- $f$  : coefficient given in Tab 15 depending on the conditions of fixing of the pillar.

c) Critical stress for local buckling of pillars

- For local buckling behaviour of a pillars made of aluminium alloy, the admissible stress  $\sigma_{cl}$ , in N/mm<sup>2</sup>, is given by the formula:

$$\sigma_{cl} = 2 \cdot R_{p0,2} \cdot C$$

where:

- $C$  : coefficient as defined in [8.10.2] b),

$$\lambda = \frac{R_{p0,2}}{\sigma_{El}}$$

- $R_{p0,2}$  : minimum as-welded guaranteed yield stress of aluminium alloy used, in N/mm<sup>2</sup>,

$\sigma_{El}$  : stress defined below.

- For tubular pillars with a rectangular cross-section, the stress  $\sigma_{El}$ , in N/mm<sup>2</sup>, is given by:

$$\sigma_{El} = 252000 \cdot \left(\frac{t}{b}\right)^2$$

where:

- $b$  : greatest dimension of the cross-section, in mm,
- $t$  : plating thickness, in mm.

- For tubular pillars with a circular cross-section, the stress  $\sigma_{El}$ , in N/mm<sup>2</sup>, is given by:

$$\sigma_{El} = 43000 \cdot \frac{t}{D}$$

$D$  : outer diameter, in mm,

$t$  : plating thickness, in mm.

- For pillars with I cross-sections, the stress  $\sigma_{El}$ , in N/mm<sup>2</sup>, is the lesser of the following values:

$$\sigma_{El} = 252000 \cdot \left(\frac{t_w}{h_w}\right)^2$$

$$\sigma_{El} = 105000 \cdot \left(\frac{t_f}{b_f}\right)^2$$

where:

$t_w$  : web thickness, in mm,

$h_w$  : web height, in mm,

$t_f$  : thickness of face plate, in mm,

$h_f$  : width of face plate, in mm.

d) Scantlings of pillars

- The scantlings of pillars are to comply with the following requirements:

$$\sigma \leq \sigma_c$$

$$\sigma \leq \sigma_{cl}$$

where:

- $\sigma$  : compressive stress, in N/mm<sup>2</sup>, in the pillar due to load  $Q$ ,

$$\sigma = 10 Q/A,$$

$A$  being the cross-sectional area, in cm<sup>2</sup>, of the pillars,

- $\sigma_c$  : overall buckling critical stress, as defined in [8.10.2] b) above,

- $\sigma_{cl}$  : local buckling critical stress, as defined in [8.10.2] c) above.

- The maximum allowable axial load, in kN, is the smaller of the following two values:

$$P_c = \sigma_c \cdot A \cdot 10^{-1}$$

$$P_{cl} = \sigma_{cl} \cdot A \cdot 10^{-1}$$

Table 15 : Coefficient f

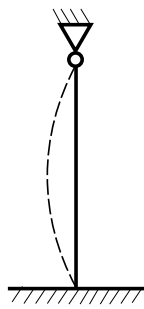

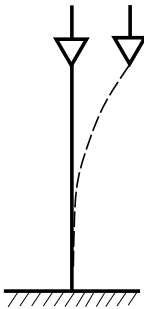
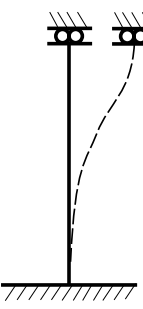
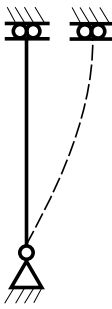
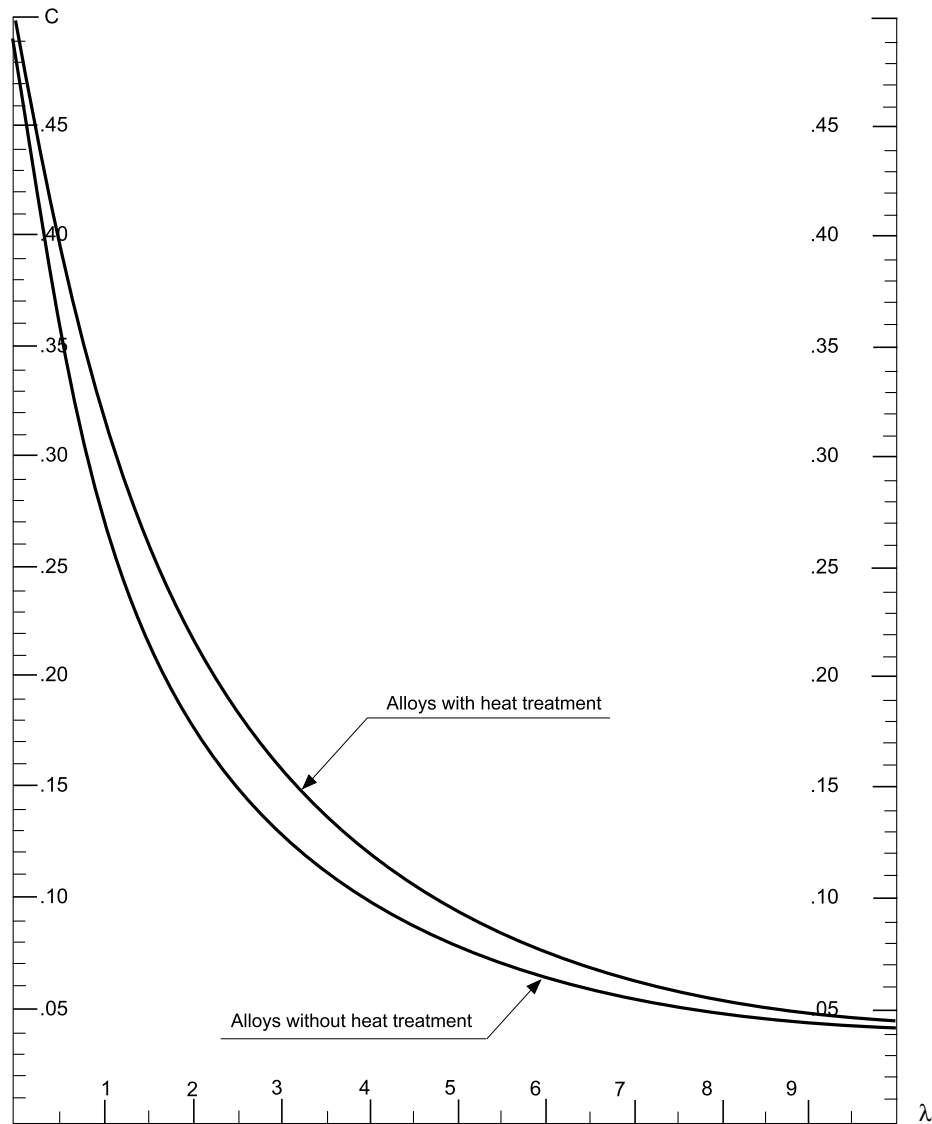
Conditions of fixity					
f	0,7	1,0	2,0	1,0	2,0

Figure 7 : Coefficient C



**8.11 Tank bulkheads**

**8.11.1 General**

Hollow profiles are not permitted as tank walls or in tanks for flammable liquids.

**8.11.2 Plating**

The thickness, in mm, is given by the following formula required for the purposes of resistance to design pressure:

$$t = 22,4 \cdot f_m \cdot \mu \cdot s \cdot \sqrt{\frac{p_t}{\sigma_{am}}}$$

where:

- $f_m$  : coefficient depending on the material:
  - $f_m = 0,80$  for steel structures
  - $f_m = 0,75$  for aluminium alloy structures,
- $p_t$  : design pressure, in  $kN/m^2$ , as defined in [6.8],

- $\sigma_{am}$  :
  - steel structures:  
 $\sigma_{am} = 185/K$  ( $N/mm^2$ )
  - aluminium alloy structures:  
 $\sigma_{am} = 85/K$  ( $N/mm^2$ ).

In addition, thickness is also to comply with [8.7.3].

**8.11.3 Ordinary stiffeners**

The section modulus, shear area and welding section required for ordinary stiffeners are given by the formulae in [8.8.2], assuming:

- $p$  : design pressure  $p_t$  as defined in [6.8],
- $m$  : coefficient depending on the type of stiffener and support conditions at the ends of the stiffener span, to be taken according to Tab 12,
- $\sigma_{am}, \tau_{am}$  :
  - steel structures:  
 $\sigma_{am} = 150/K$  ( $N/mm^2$ )  
 $\tau_{am} = 90/K$  ( $N/mm^2$ ),

- aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>).

**8.11.4 Primary supporting members**

The section modulus, shear area and welding section required for horizontal and vertical girders are given by the formulae in [8.9.2], assuming:

- $p$  : design pressure  $p_t$  as defined in [6.8],
- $m$  : coefficient depending on support conditions at the ends of the girder span, generally to be taken equal to 10. A value of 12 could be accepted if supported by direct calculation,

- $\sigma_{am}, \tau_{am}$  :
  - steel structures:  
 $\sigma_{am} = 150/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 90/K$  (N/mm<sup>2</sup>),
  - aluminium alloy structures:  
 $\sigma_{am} = 70/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 45/K$  (N/mm<sup>2</sup>).

**8.11.5 Corrugated bulkheads**

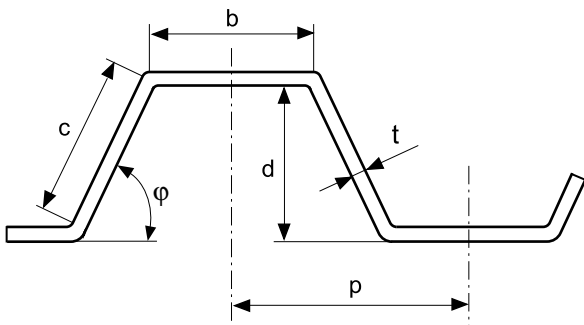
The thickness and section modulus of corrugated bulkheads, calculated as stated in [8.11.2] to [8.11.4] are to be increased by 10% and 20%, respectively.

The section modulus  $W_c$ , in cm<sup>3</sup>, of a corrugation may be derived from the following formula:

$$W_c = d t (3 b + c) / 6000$$

where the symbols are as shown in Fig 8 and are expressed in mm. In no case is the angle  $\phi$  to be less than 40°.

Figure 8 :



**8.12 Subdivision bulkheads**

**8.12.1 Plating**

The thickness required for the purposes of resistance to design pressure, in mm, is given by the following formula:

$$t = 22,4 \cdot f_m \cdot \mu \cdot s \cdot \sqrt{\frac{p_{sb}}{\sigma_{am}}}$$

where:

- $f_m$  : coefficient depending on the material:
  - $f_m = 0,75$  for steel structures
  - $f_m = 0,70$  for aluminium alloy structures,
- $p_{sb}$  : design pressure, in kN/m<sup>2</sup>, as defined in [6.9],
- $\sigma_{am}$  :
  - steel structures:  
 $\sigma_{am} = 235/K$  (N/mm<sup>2</sup>)
  - aluminium alloy structures:  
 $\sigma_{am} = 95/K$  (N/mm<sup>2</sup>).

The thickness of the collision bulkhead is to be multiplied by 1,15.

In addition, thickness is also to comply with [8.7.3].

**8.12.2 Ordinary stiffeners**

The section modulus, shear area and welding section required for ordinary stiffeners are given by the formulae in [8.8.2], assuming:

- $p$  : design pressure  $p_{sb}$  as defined in [6.9],
- $m$  : coefficient depending on the type of stiffener and support conditions at the ends of the stiffener span, to be taken according to Tab 12,

- $\sigma_{am}, \tau_{am}$  :
  - steel structures:  
 $\sigma_{am} = 210/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 120/K$  (N/mm<sup>2</sup>),
  - aluminium alloy structures:  
 $\sigma_{am} = 95/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 55/K$  (N/mm<sup>2</sup>).

The section modulus, shear area and welding section required for the ordinary stiffeners of the collision bulkhead are to be calculated from [8.12.2], considering  $\sigma_{am}$  and  $\tau_{am}$  divided respectively by 1,15 and 1,05.

**8.12.3 Primary supporting members**

The section modulus, shear area and welding section required for horizontal and vertical girders are given by the formulae in [8.9.2], assuming:

- $p$  : design pressure  $p_{sb}$  as defined in [6.9],
- $m$  : coefficient depending on support conditions at the ends of the girder span, generally to be taken equal to 10,

- $\sigma_{am}, \tau_{am}$  :
  - steel structures:  
 $\sigma_{am} = 210/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 120/K$  (N/mm<sup>2</sup>),
  - aluminium alloy structures:  
 $\sigma_{am} = 95/K$  (N/mm<sup>2</sup>)  
 $\tau_{am} = 55/K$  (N/mm<sup>2</sup>).

The section modulus, shear area and welding section required for the primary supporting members of the collision bulkhead are to be calculated from [8.12.3], considering  $\sigma_{am}$  and  $\tau_{am}$  divided respectively by 1,3 and 1,2.

**8.12.4 Corrugated bulkheads**

The thickness and section modulus of corrugated bulkheads, calculated as stated in [8.12.1] to [8.12.3], are to be increased by 10% and 20%, respectively.

The section modulus of a corrugation is to be calculated as indicated in [8.11.5].

### 8.13 Non-tight bulkheads

**8.13.1** The thickness of plating of non-tight bulkheads which do not act as pillars is to be not less than 2 mm for steel bulkheads, and 3 mm for aluminium alloy bulkheads, and vertical stiffeners are to be not more than 900 mm apart.

**8.13.2** Vertical stiffeners of bulkheads which do not act as pillars are to have a section modulus (calculated in association with a width of plating equal to the stiffener spacing but not exceeding 750 mm) not less than the value, in  $\text{cm}^3$ , given by the formula:

$$Z = 2 s S^2$$

**8.13.3** The thickness of plating of non-tight bulkheads which act as pillars is to be not less than 2 mm for steel bulkheads, and 3 mm for aluminium alloy bulkheads, and vertical stiffeners are to be not more than 750 mm apart.

**8.13.4** Vertical stiffeners of bulkheads which act as pillars are to have a section modulus (calculated in association with a width of plating equal to the stiffener spacing but not exceeding 750 mm) not less than the value, in  $\text{cm}^3$ , given by the formula:

$$Z = 2,65 s S^2$$

**8.13.5** In addition, each vertical stiffener, in association with a width of plating equal to 50 times the plating thickness, is to comply with the requirements for pillars given in [8.10], the load supported being determined in accordance with the same provisions.

**8.13.6** In the case of tanks extending from side to side, a wash bulkhead is generally to be fitted amidships; the plating thickness is to be not less than 2 mm for steel bulk-

heads, and 3 mm for aluminium alloy bulkheads, and it is to be strengthened by vertical stiffeners.

### 8.14 Independent prismatic tanks

**8.14.1** The required thickness for the plating of independent prismatic tanks, in mm, is given by the formula:

$$t = 1,25 \cdot f_m \cdot s \cdot \mu \cdot (p_t \cdot K)^{0,5}$$

where:

$f_m$  : coefficient depending on the material:

- $f_m = 1,0$  for steel bulkheads
- $f_m = 1,45$  for aluminium alloy bulkheads,

$p_t$  : design pressure, in  $\text{kN/m}^2$ , as defined in [6.8].

**8.14.2** In no case is the thickness to be less than 2,5 mm for steel bulkheads, and 3,5 mm for aluminium alloy bulkheads.

**8.14.3** The section modulus required for stiffeners, in  $\text{cm}^3$ , is given by the formula:

$$Z = 0,4 \cdot f'_m \cdot s \cdot \ell^2 \cdot p_t \cdot K$$

where:

$f'_m$  : coefficient depending on the material:

- $f'_m = 1,0$  for steel bulkheads
- $f'_m = 2,15$  for aluminium alloy bulkheads.

**8.14.4** The connections to reinforced hull structures of independent tanks are to be able to withstand the dynamic loads induced by the tank weight and the acceleration  $a_v$  of the craft (see [4]).

**8.14.5** It is recommended that stiffener plates should be arranged so as to prevent undue movement of the liquid.

## SECTION 4

## OUTFITTINGS

## 1 Hull appendages

## 1.1 Propeller shaft brackets

## 1.1.1 General

For certain ships, the propeller shafting is extended to the propeller bearings clear of the main hull.

Propeller shafting is either enclosed in bossing or independent of the main hull and supported by shaft brackets.

## 1.1.2 Shaft brackets

The scantlings of bracket arms are to be calculated as indicated below. For high-powered ships, the Society may require direct calculations to be carried out.

Bracket arms are to be attached to deep floors or girders of increased thickness, and the shell plating is to be increased in thickness and suitably stiffened, at the discretion of the Society. The thickness of the palm connecting the arms to the hull, if any, is to be not less than  $0,2 d_s$ , where:

$d_s$  : Rule diameter, in mm, of the propeller shaft, calculated with the actual mechanical characteristics,

and it is to be connected to the hull by means of through bolts, fitted with nut and lock nut, in way of the internal hull structures suitably stiffened.

The arms of V-shaft brackets are to be perpendicular, as far as practicable.

The bearing length of the shaft bracket boss, in mm, is to be not less than  $3 d_s$ .

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

$$t_b = 0,2 \cdot d_s \cdot (k_1 + 0,25)$$

where:

$$k_1 = R_{ms} / R_{mb}$$

$R_{ms}$  : minimum tensile strength, in N/mm<sup>2</sup>, of the propeller shaft,

$R_{mb}$  : minimum tensile strength, in N/mm<sup>2</sup>, of the shaft bracket boss, with appropriate metallurgical temper.

Each arm of V-shaft brackets is to have a cross-sectional area, in mm<sup>2</sup>, not less than:

$$S = 87,5 \cdot 10^{-3} \cdot d_{so}^2 \cdot \left( \frac{1600 + R_{ma}}{R_{ma}} \right)$$

where:

$d_{so}$  : rule diameter, in mm, of the propeller shaft, for a carbon steel material,

$R_{ma}$  : minimum tensile strength, in N/mm<sup>2</sup>, of arms, with appropriate metallurgical temper.

Single-arm shaft brackets are to have a section modulus at ship plating level, in cm<sup>3</sup>, not less than:

$$W = \frac{30}{R_{ma}} \cdot 10^{-3} \cdot \ell \cdot d_{so}^2 \cdot \sqrt{n \cdot d_{so}}$$

where:

$\ell$  : length of the arm, in m, measured from the shell plating to the centreline of the shaft boss,

$n$  : shaft revolutions per minute.

Moreover, the cross-sectional area of the arm at the boss is not to be less than 60% of the cross-sectional area at shell plating.

## 1.1.3 Plated bossing

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

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

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

Stiffening of the boss plating is to be individually considered. At the aft end, transverse diaphragms are to be fitted at every frame and connected to floors of increased scantlings. At the fore end, web frames spaced not more than four frames apart are to be fitted.

## 1.2 Waterjets

1.2.1 The supporting structures of waterjets are to be able to withstand the loads thereby generated in the following conditions:

- maximum ahead thrust,
- maximum thrust at maximum lateral inclination,
- maximum reversed thrust (going astern).

Information on the above loads is to be given by the waterjet manufacturer and supported by documents.

1.2.2 For each waterjet, following loading cases are to be investigated:

LDC 1 : internal hydrodynamic pressure  $p_h$  in the built-in nozzle

LDC 2 : horizontal longitudinal force  $F_{x1}$  in normal service (ahead)

LDC 3 : horizontal transverse force  $F_y$  and associated moment  $M_z$  during steering operation

LDC 4 : horizontal longitudinal force  $F_{x2}$ , vertical force  $F_z$  and overturning moment  $M_y$  in crash-stop situation

1.2.3 The actual location of the thrust bearing is to be adequately considered (either located aft of the stem in the stator bowl or inside the waterjet compartment).

**1.2.4** The scantlings are to be checked by direct calculations.

**1.2.5** indicates the loading cases to be considered for the various components of the waterjet system. Other loading cases could be considered for specific or new design.

**Table 1 :**

Component	LDC 1	LDC 2	LDC 3	LDC 4
Built-in nozzle:				
- plating	X (1)	X (2)		
- bending behaviour				X (3)
Ship stem		X (2)	X	X (4)
Bolting on stem			X (5)	X (5)
<p>(1) : to be checked under lateral pressure and against fatigue behaviour            (2) : buckling to be checked (100% of <math>F_x</math> transferred by built-in nozzle in case of thrust bearing aft of the stem)            (3) : ratio of <math>M_y</math> directly sustained by the built-in nozzle to be estimated on basis of relative stiffnesses            (4) : ratio of <math>M_y</math> directly sustained by the transom structure to be estimated on basis of relative stiffnesses            (5) : bolting calculation taking account of the actual pre-tension in bolts</p>				

**1.2.6** The stress criteria for static analysis may be taken as the following one, in N/mm<sup>2</sup>:

- bending stress:

$$\sigma_{am} = \frac{150}{K \cdot f'_m}$$

- shear stress:

$$\tau_{am} = \frac{90}{K \cdot f'_m}$$

- Von Mises equivalent bending stress:

$$\sigma_{eq, am} = \frac{190}{K \cdot f'_m}$$

where:

K : material factor defined in Sec 3, [3]

$f'_m$  : coefficient depending on the material:

- 1,00 for steel structures
- 2,15 for aluminium alloy structures

**1.2.7** The stress criteria for fatigue analysis are to be specified by the designer.

**1.2.8** The shell thickness in way of nozzles as well as the shell thickness of the tunnel are to be individually considered. In general, such thicknesses are to be not less than 1,5 times the thickness of the adjacent bottom plating.

**1.2.9** General principles to be followed for such structures subject to cyclic loadings are listed hereafter:

- continuous welding
- shear connections between stiffeners and transverse frames
- soft toe brackets
- no sniped ends
- no termination on plate fields
- no scallops in critical areas
- no start and stop of welding in corners or at ends of stiffeners and brackets
- possibly grinding of toes of critical welds

Note 1: As a guidance, the following criteria may be considered:

The bending natural frequency of plates and strength members of the hull in the area of waterjets should not be less than 2,3 times the blade frequency for structures below the design waterline and between transom and aft engine room bulkhead. Structural components (such as the casing of waterjet and accessory parts and the immersed shell area) which may transfer pressure fluctuations into the ship structure have to fulfill the requirements of the waterjet manufacturer. Especially with regard the grids installed in the inlet duct, the hydrodynamic design should assure an unproblematic operation with respect to cavitation phenomenon.

This checking is left to the manufacturers.

## 2 Rudders

### 2.1 General

**2.1.1** Rudders which are intended to be operated at the maximum angle of helm only during navigation at reduced speed are to comply with the provisions of this article.

**2.1.2** This article applies to rudders having a rectangular or trapezoidal blade contour without cutouts, of the types shown in Fig 9 and Figure 10. Rudders of different types is to be individually considered by the Society.

**2.1.3** Rudders which are intended to be operated at the maximum angle of helm during high speed navigation are to be designed on the basis of direct calculations to be performed by the designer. The acceptability of calculated results are to be individually considered by the Society in each separate case.

### 2.2 Definitions and symbols

#### 2.2.1

$V_{AV}$  : maximum ahead service speed, in knots, at maximum displacement, in still water,

A : total area of rudder blade, in m<sup>2</sup>, bounded by the blade external contour, including mainpiece and the part forward of the centreline of the rudder pintles, if any,

$A_D$  : area, in m<sup>2</sup>, of the rudder part abaft the centreline of rudder pintles,

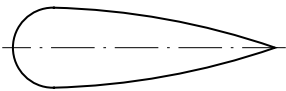
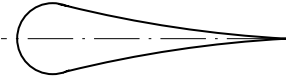
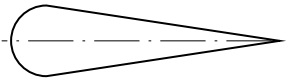
$X_G$  : distance, in m, from the centroid of area A to the centreline of pintles,

$k_1$  : shape factor, equal to:

$$k_1 = (\Lambda + 2) / 3$$

- $\Lambda$  :  $\Lambda = h^2 / A_T$   
 where h is the mean height of the rudder area, in m. In no case is the value of  $\Lambda$  to be greater than 2. Mean height h and mean breadth b of rudder blade are to be calculated according to ,
- $A_T$  : area, in m<sup>2</sup>, obtained by adding, to the rudder blade area, the area of rudder post or rudder horn, if any, up to height h,
- $k_2$  : factor depending on rudder profile, the value of which is given in Tab 2. For high-efficiency rudders,  $k_2$  is to be equal to 1,7 for ahead condition and 1,2 for astern condition,
- $k_3$  : factor equal to:
- $k_3 = 0,8$  for rudders outside the propeller jet
  - $k_3 = 1,15$  for rudders behind a fixed propeller nozzle
  - $k_3 = 1,0$  in other cases,
- $d_{TF}$  : rule diameter, in mm, of rudder stock subject to combined torque and bending,
- $d_T$  : rule diameter, in mm, of rudder stock subject to torque only,
- $C_R$  : rudder force, in N, i.e. force acting on the rudder blade, as defined in [2.5],
- $Q_R$  : rudder torque, in N · m, i.e. torque acting on the rudder stock, as defined in [2.5].

**Table 2 : Factor  $k_2$**

Profile type	$k_2$	
	ahead condition	astern condition
NACA-00 – Göttingen profiles 	1,10	0,80
Hollow profiles 	1,10 - 1,35	0,90
Flat side profiles 	1,10	0,90

**2.3 Materials**

**2.3.1** Rudder stocks, pintles, keys and bolts are to be made of rolled, forged or cast C-Mn steel, in accordance with the relevant requirements of the Rules.

**2.3.2** The material used for rudder stocks, pintles, keys and bolts is to have a minimum yield stress  $R_{eH}$  of not less than 200 N/mm<sup>2</sup>.

**2.3.3** The requirements for the determination of scantlings contained in this article apply to steels having a minimum yield stress  $R_{eH}$  equal to 235 N/mm<sup>2</sup>.

**2.3.4** In the case of steels with a yield stress  $R_{eH}$  other than 235 N/mm<sup>2</sup>, the values of diameters and thicknesses calculated with the formulae contained in the following sub-articles are to be modified as indicated, depending on the factor  $K_1$  obtained from the following formula:

$$K_1 = \left( \frac{235}{R_{eH}} \right)^y$$

where:

$R_{eH}$  : minimum yield stress of steel used, in N/mm<sup>2</sup>; in no case is  $R_{eH}$  to be greater than 450 N/mm<sup>2</sup> or 0,7  $R_m$ , whichever is less,

$R_m$  : minimum ultimate tensile strength of steel employed, in N/mm<sup>2</sup>,

- for  $R_{eH} > 235$  N/mm<sup>2</sup>:  $y = 0,75$
- for  $R_{eH} \leq 235$  N/mm<sup>2</sup>:  $y = 1,0$

**2.3.5** In general, significant reductions in rudder stock diameter for the application of steels with  $R_{eH} > 235$  N/mm<sup>2</sup> may be accepted by the Society, subject to the results of a calculation to check rudder stock deformation.

**2.3.6** Significant rudder stock deformations are to be avoided so as not to create excessive edge pressures in way of bearings.

**2.3.7** Welded parts of rudders are to be made of rolled hull steels of a type approved by the Society.

**2.4 Arrangement**

**2.4.1** Effective means are to be provided to support the weight of the rudder without excessive bearing pressure (e.g. by means of 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.

**2.4.2** Suitable arrangements are to be made to prevent the rudder from accidental lifting.

**2.4.3** In addition, structural rudder stops of suitable strength are to be provided, except where the steering gear is provided with its own rudder stopping devices.

**2.4.4** 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 lubricant being washed away from the rudder carrier.

If the top of the rudder trunk is below the deepest waterline, two separate seals or stuffing boxes are to be provided.

## 2.5 Determination of the force acting on the rudder blade and the torque acting on the rudder stock

**2.5.1** The rudder force  $C_R$ , in N, is to be calculated by the following formula:

$$C_R = 132 \cdot A \cdot V^2 \cdot k_1 \cdot k_2 \cdot k_3$$

where:

$$V : \min[V_{AV}, 2/3 \cdot (V_{AV} + 2 \cdot L^{0.5})]$$

**2.5.2** The rudder torque  $Q_R$ , in  $N \cdot m$ , is to be calculated for both ahead and astern conditions according to the formula:

$$Q_R = C_R \cdot r$$

where:

$r$  : distance, in m, equal to:

$$r = b \cdot (\alpha - k_A)$$

for the ahead condition,  $r$  is to be taken not less than  $0,1 \cdot b$ ,

$b$  : mean breadth of rudder area, in m, measured in accordance with Fig 3,

$\alpha$  : • for ahead condition:  $\alpha = 0,33$

• for astern condition:  $\alpha = 0,66$

$$k_A = A_F / A$$

$A_F$  being the area, in  $m^2$ , of the rudder blade portion afore the centreline of rudder pintles (see Fig 3).

## 2.6 Rudder stock

### 2.6.1 Rudder stock subject to torque

Rudder stocks subject to torque are to have scantlings such that the torsional stress, in  $N/mm^2$ , does not exceed the following value:

$$\tau_{T \text{ ALL}} = 68/K_1$$

The rudder stock diameter is therefore to be not less than  $d_T$ , in mm, calculated by the following formula:

$$d_T = 4,2 \cdot (Q_R \cdot K_1)^{1/3}$$

### 2.6.2 Rudder stock subject to combined torque and bending

a) Rudder stocks subject to combined torque and bending are to have scantlings such that their equivalent stress  $\sigma_e$ , in  $N/mm^2$ , does not exceed the value determined by the formula:

$$\sigma_{e \text{ ALL}} = 118 / K_1$$

b)  $\sigma_e$  is given by the formula:

$$\sigma_e = \sqrt{\sigma_B^2 + 3 \cdot \tau_T^2}$$

where:

$\sigma_B$  : bending stress component, in  $N/mm^2$ , given by the formula:

$$\sigma_B = \frac{10,2 \cdot M}{d_{TF}^3} \cdot 10^3$$

$\tau_T$  : torsional stress component, in  $N/mm^2$ , given by the following formula:

$$\tau_T = \frac{5,1 \cdot Q_R}{d_{TF}^3} \cdot 10^3$$

c) The rudder stock diameter, in mm, is therefore to be not less than the value  $d_{TF}$ , in mm, calculated according to the formula:

$$d_{TF} = d_T \cdot \left(1 + \frac{4}{3} \cdot \left(\frac{M}{Q_R}\right)^{3/16}\right)$$

where:

$M$  : bending moment, in  $N \cdot m$ , which may be expressed as:

$$M = 0,866 \cdot (C_R / A) \cdot H$$

$H$  : • for spade rudders (see ):

$$H = A_2 \cdot (H_C + H_2 / 2)$$

• for rudders with 2 bearings (with solepiece) (see Fig 2):

$$H = A_1 \cdot a_1 \cdot u \cdot H_1$$

$A_1$ ,  $A_2$ ,  $H_C$ ,  $H_1$  and  $H_2$  are shown in Fig 1 and Fig 2.

Figure 1 :

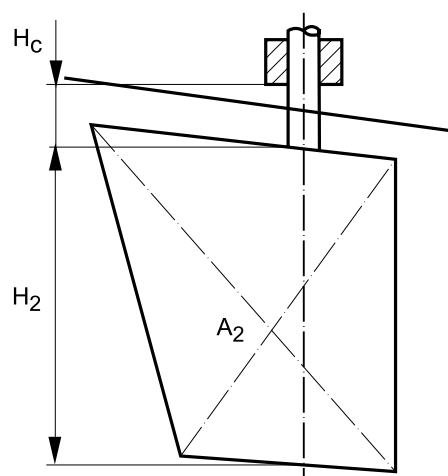
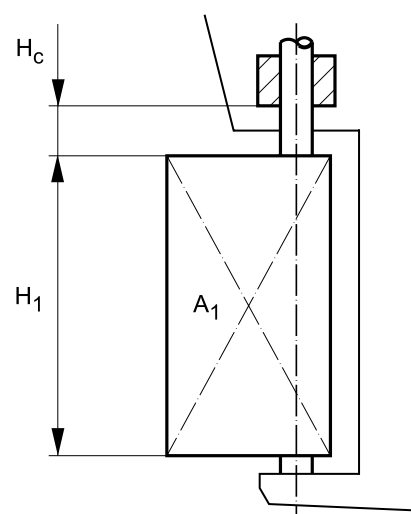


Figure 2 :



The values of the coefficients  $a_1$  and  $u$  are given in Tab 3 as a function of the ratio  $c$ , where:

$$c = H_1 / (H_C + H_1)$$

- d) The Society may accept bending moments, shear forces and support reaction forces determined by a direct calculation to be performed with reference to the static schemes and loading conditions set out in Fig 4 and Fig 5.

For the rudder in Fig 4, the load per unit length  $P_R$ , in kN/m, is given by:

$$P_R = C_R \cdot \frac{10^{-3}}{\ell_{10}}$$

For the rudder in Fig 5, the maximum bending moment  $M_B$ , in N · m, and support forces  $B_3$  and  $B_2$ , in N, may be determined by the formulae:

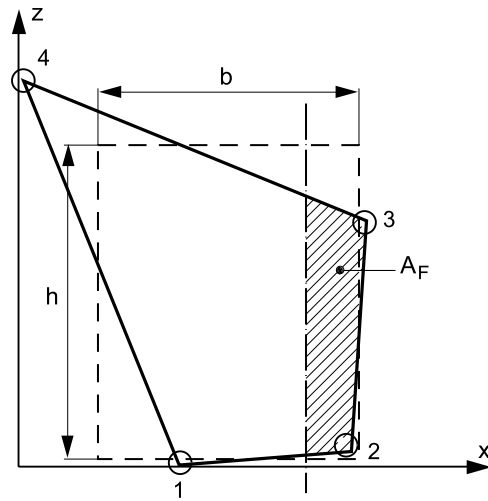
$$M_B = C_R \cdot \left( \ell_{20} + \frac{\ell_{10} \cdot (2C_1 + C_2)}{3 \cdot (C_1 + C_2)} \right)$$

$$B_3 = M_B / \ell_{30}$$

$$B_2 = C_R + B_3$$

- e) In general, the diameter of a rudder stock subject to torque and bending may be gradually tapered above the upper stock bearing, so as to reach the value of  $d$  in way of the quadrant or tiller.

Figure 3 :



- $b$  : mean breadth of rudder, in m, equal to:  

$$b = \frac{x_2 + x_3 - x_1}{2}$$
- $h$  : mean height of rudder, in m, equal to:  

$$h = \frac{z_3 + z_4 - z_2}{2}$$

Figure 4 :

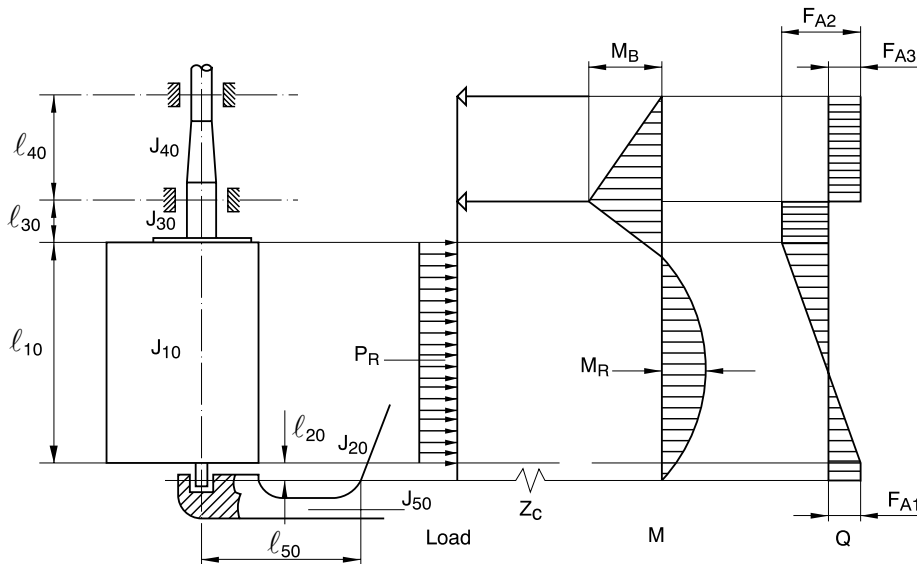


Figure 5 :

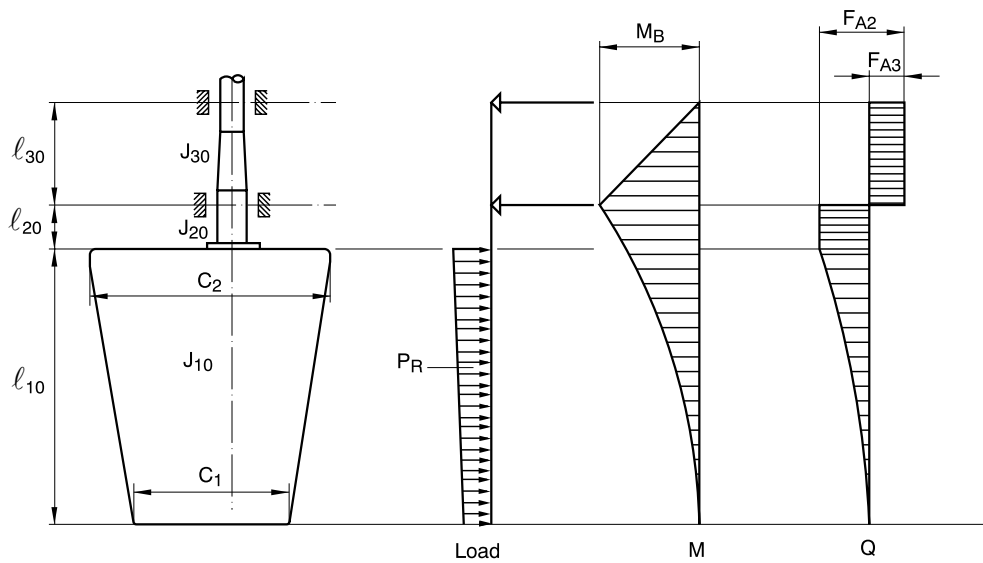


Table 3 : Coefficients a<sub>1</sub> and u

c	u	a <sub>1</sub>	c	u	a <sub>1</sub>
1,00	0,2490	1,000	0,74	0,2694	1,266
0,98	0,2370	1,000	0,72	0,2784	1,302
0,96	0,2294	1,000	0,70	0,2881	1,336
0,94	0,2256	1,000	0,68	0,2984	1,370
0,92	0,2242	1,000	0,66	0,3094	1,403
0,90	0,2248	1,000	0,64	0,3212	1,435
0,88	0,2270	1,000	0,62	0,3336	1,467
0,86	0,2303	1,017	0,60	0,3468	1,499
0,84	0,2348	1,064	0,58	0,3608	1,531
0,82	0,2402	1,109	0,56	0,3757	1,563
0,80	0,2464	1,151	0,54	0,3915	1,596
0,78	0,2534	1,191	0,52	0,4084	1,629
0,76	0,2610	1,229	0,50	0,4264	1,662

**2.7 Rudder plating**

**2.7.1** Double-plating rudders consist of a welded plating box, stiffened by horizontal and vertical webs, which may or may not incorporate the mainpiece.

**2.7.2** The generic horizontal cross-section of the rudder plating is to be such that stress components, in N/mm<sup>2</sup>, do not exceed the following values:

- normal bending stress:  
 $\sigma_{F1} = 110 / K_1$
- shear stress:  
 $\tau = 50 / K_1$
- equivalent stress:  
 $\sigma_e = \sqrt{\sigma_{F1}^2 + 3 \cdot \tau^2} = \frac{120}{K_1}$

**2.7.3** The thickness of each rudder plate panel is to be not less than t<sub>F</sub>, in mm, calculated by the following formula:

$$t_F = \left( 5,5 \cdot s \cdot \beta \cdot \sqrt{d + \frac{C_R \cdot 10^{-4}}{A} + 2,5} \right) \cdot \sqrt{K_1}$$

where:

d : draught at summer load waterline, in m,

$$\beta = \sqrt{1,1 - 0,5 \cdot \left(\frac{s}{b_L}\right)^2}$$

which need not be greater than 1,

with:

s : minor side of the plating panel, in m,

b<sub>L</sub> : major side of the plating panel, in m.

**2.7.4** Vertical webs with spacing greater than twice that of horizontal webs are not acceptable.

**2.7.5** Web thickness is to be at least 70% of that required for rudder plating, and in no case is it to be less than 8 mm, except for the upper and lower webs. The thickness of any of these webs is to be uniform and not less than that of the web panel having the greatest thickness t<sub>F</sub> as calculated with the above formula. In any case the thickness is not required to be increased by more than 20% compared with normal webs.

**2.7.6** When the design of the rudder does not incorporate a mainpiece, this is to be replaced by two vertical webs closely spaced and in general not less than 1,5 times the thickness of normal webs. In rudders with an area A smaller than 5 m<sup>2</sup>, one vertical web may be accepted, provided its thickness is in general at least twice that of normal webs. As a rule, the increased thickness of such webs need not exceed 30 mm, unless otherwise required in special cases to be individually considered by the Society.

The thickness of the side plating between the two vertical webs replacing the mainpiece, or in way of the single web, is to be increased by at least 20%.

**2.7.7** The welded connections of blade plating to vertical and horizontal webs are to comply with the requirements of Sec 3, [3].

Where internal access to the rudder is not practicable, connections are to be made by slots on a supporting flat welded to the webs, to be cut on one side of the rudder only, in accordance with Sec 3, [3].

**2.7.8** Rudder nose plates are to have a thickness not less than  $1,25 t_f$ . In general this thickness need not exceed 22 mm, unless otherwise required in special cases to be individually considered by the Society.

**2.8 Rudder pintles**

**2.8.1** Rudder pintles are to have a diameter not less than the value  $d_A$ , in mm, calculated by the formula:

$$d_A = 0,35 \cdot (F_A \cdot K_1)^{1/2}$$

where:

$F_A$  : force, in N, acting on the pintle, calculated as specified in [2.8.7].

**2.8.2** Provision is to be made for a suitable locking device to prevent the accidental loosening of pintles.

**2.8.3** The pintle housings are in general to be tapered with the taper ranging:

- from 1:12 to 1:8 for pintles with non-hydraulic assembly and disassembly arrangements,
- from 1:20 to 1:12 for pintles with hydraulic assembly and disassembly arrangements.

The housing height is to be not less than the pintle diameter  $d_A$ .

**2.8.4** The maximum value of the pressure acting on the gudgeons, in N/mm<sup>2</sup>, calculated by the formula:

$$p_F = \frac{F_A}{d_A \cdot h_A}$$

is not to exceed the values given in Tab 4, where  $h_A$  is the length of contact between pintle and housing, taken to be not greater than  $1,2 d_A$ .

Values in excess of those given In Tab 4 may be accepted by the Society on the basis of specific tests.

**2.8.5** The thickness of the pintle housing in the gudgeon is to be not less than  $0,25 d_A$ .

**2.8.6** The manufacturing tolerances, in mm, on the diameter of metal supports are to be less than:

**Table 4 :**

Bearing material	$q_a$ (N/mm <sup>2</sup> )
Lignum vitae	2,5
White metal, oil lubricated	4,5
Synthetic material with hardness between 60 and 70 Shore D <b>(1)</b>	5,5
Steel, bronze and hot-pressed bronze-graphite materials <b>(2)</b>	7,0
<b>(1)</b> Indentation hardness test at 23°C and with 50% moisture to be performed according to a recognised standard. Type of synthetic bearing materials to be approved by the Society.	
<b>(2)</b> Stainless and wear-resistant steel in combination with stock liner approved by the Society.	

$$d_A / 1000 + 1,0$$

In the case of non-metal supports, tolerances are to be evaluated carefully on the basis of the thermal and distortion properties of the materials employed; the tolerance on the support diameter is in no case to be less than 1,5 mm.

**2.8.7** Where direct calculation is used to obtain the rudder stock stress components, the value  $F_A$  is also to be derived from the same calculation.

Otherwise,  $F_A$  is to be calculated from the following formula:

$$F_A = \frac{C_R}{A} \cdot A_G$$

where:

$C_R$  : force, in N, acting on the rudder blade, determined as specified in [2.5],

$A_G$  : part of the rudder blade area  $A$ , in m<sup>2</sup>, supported by the pintle.  $A_G$  is to be not lower than:

$$A_G = A \cdot \frac{H_C + 0,5 \cdot H_1}{H_C + H_1}$$

**2.9 Rudder couplings**

**2.9.1 Horizontal flange couplings**

a) Horizontal flange couplings are to be connected by a number  $n_B$  of fitted bolts not fewer than 6, and the diameter of which, in mm, is not less than  $d_B$  given by the formula:

$$d_B = 0,62 \cdot \frac{K_{1B}}{K_{1A}} \cdot \sqrt{\frac{d_i^3}{n_B \cdot e_M}}$$

b) The thickness of the coupling flange is to be not less than the value  $t_p$ , in mm, calculated by the following formula:

$$t_p = d_B \cdot \sqrt{\frac{K_{1P}}{K_{1B}}}$$

In any case  $t_p \geq 0,9 d_B$ ,

with  $d_B$  calculated for a number of bolts not exceeding 8.

The symbols used above have the following meaning:

- $d_1$  : rule diameter  $d_T$  or  $d_{TF}$ , in mm, of the rudder stock, in compliance with the requirements in [2.6],
- $K_{1B}$ ,  $K_{1A}$ ,  $K_{1P}$ : coefficients depending on the high-strength steel used for bolts, rudder stock and coupling flange, respectively, whose values are defined in [2.6],
- $e_M$  : mean distance, in mm, of the bolt axes from the longitudinal axis through the coupling centre.
- c) The distance from the bolt axes to the external edge of the coupling flange is generally to be not less than  $1,2 d_B$ .
- d) A suitable locking device is to be provided to prevent accidental loosening of nuts.
- e) Non-fitted bolts may be used provided that, in way of the mating plane of the coupling flanges, a key is fitted with a section of  $0,25 d_T \times 0,10 d_T$  and keyways in both the coupling flanges, and provided that at least two of the coupling bolts are fitted bolts.

### 2.9.2 Vertical flange couplings

- a) Vertical flange couplings are to be connected by a number  $n_B$  of fitted bolts not fewer than 8, and the diameter of which, in mm, is not less than  $d_B$  given by the formula:

$$d_B = 0,81 \cdot d_1 \cdot \sqrt{\frac{K_{1B}}{n_B \cdot K_{1A}}}$$

$d_1$ ,  $K_{1B}$  and  $K_{1A}$  being defined in [2.9.1]b) above.

- b) The first moment of area of the sectional area of bolts about the vertical axis through the centre of the coupling is to be not less than the value  $M_s$ , in  $\text{cm}^3$ , obtained by the formula:

$$M_s = 0,43 d_1^3 \cdot 10^{-6}$$

- c) The thickness of the coupling flange is generally to be not less than  $d_B$ .
- d) The distance of the bolt axes from the external edge of the coupling flange is generally to be not less than  $1,2 d_B$ .
- e) A suitable locking device is to be provided to prevent the accidental loosening of nuts.

### 2.9.3 Cone couplings

- a) Cone couplings of the shape shown in Fig 6 (with explanations of symbols in (a) and (b) below) are to be secured by a slugging/hydraulic nut, as the case may be, provided with an efficient locking device, and with the following dimensions:

- Cone couplings with hydraulic arrangements for assembling and disassembling the coupling:

$$\text{Taper: } 1/20 \leq (\delta_1 - d_0) / t_s \leq 1/12$$

$$t_s \geq 1,5 \cdot d_1$$

$$d_G \geq 0,65 \cdot d_1$$

$$t_N \geq 0,60 \cdot d_G$$

$$d_N \geq 1,2 \cdot d_0 \text{ and, in any case, } d_N \geq 1,2 \cdot d_G$$

A washer is to be fitted between the nut and the rudder gudgeon not less than  $0,13 \cdot d_G$  in thickness, and

with an outer diameter not less than  $1,3 \cdot d_0$  or  $1,6 \cdot d_G$ , whichever is greater.

- Cone couplings without hydraulic arrangements for assembling and disassembling the coupling:

$$\text{Taper: } 1/12 \leq (\delta_1 - d_0) / t_s \leq 1/8$$

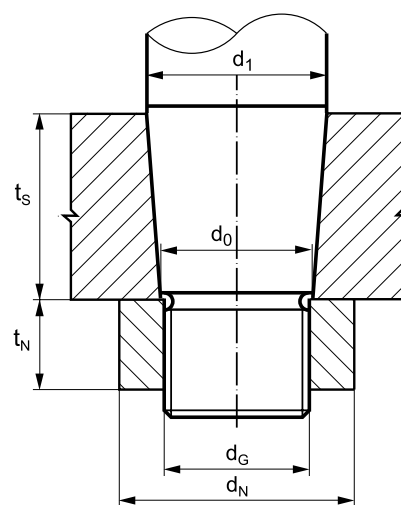
$$t_s \geq 1,5 \cdot d_1$$

$$d_G \geq 0,65 \cdot d_1$$

$$t_N \geq 0,60 \cdot d_G$$

$$d_N \geq 1,2 \cdot d_0 \text{ and, in any case, } d_N \geq 1,2 \cdot d_G.$$

Figure 6 :



- b) The dimensions of the locking nut, in both (a) and (b) above, are given purely for guidance, the determination of adequate scantlings being left to the responsibility of the designer.

- c) In cone couplings of type (b) above, a key is to be fitted with a cross-section  $0,025 \cdot d_T^2$  and keyways in both the tapered part and the rudder gudgeon.

In cone couplings of type (a) above, the key may be omitted. In this case, the designer is to provide the Society with shrinkage calculations supplying all data necessary for the appropriate check.

- d) All necessary instructions for hydraulic assembly and disassembly of the nut, including indications of the values of all relevant parameters, are to be available on board.

### 2.10 Single plate rudders

**2.10.1** The mainpiece diameter is to be calculated according to [2.6.1] b).

**2.10.2** The mainpiece diameter is to be not less than the stock diameter. For spade rudders, the lower third may taper down to  $0,75$  times the stock diameter.

**2.10.3** The blade thickness  $t_B$ , in mm, is to be not less than:

$$t_B = (1,5 \cdot s \cdot V_{AV} + 2,5) \cdot K_1^{1/2}$$

where:

s : spacing of stiffening arms, in m, in no case to be more than 1 m.

**2.10.4** The thickness of the arms is to be not less than the blade thickness; the section modulus, in cm<sup>3</sup>, of the generic cross-section is to be not less than:

$$Z_A = 0,5 \cdot s \cdot C_1^2 \cdot V_{AV}^2 \cdot K_1$$

where:

C<sub>1</sub> : horizontal distance, in m, from the aft edge of the rudder to the cross-section.

### 3 Equipment

#### 3.1 Documents to be submitted

**3.1.1** A detailed drawing, showing all the elements necessary for the evaluation of the equipment number of the crew boat, is to be submitted together with the calculations of the EN number. The anchoring equipment to be fitted on the concerned crew boat is to be specified.

**3.1.2** Windlass, brake and chain stopper are subject to approval by the Society; the relevant documentation is to be submitted.

#### 3.2 General

**3.2.1** A primary assumption made in this chapter is that crew boats will only need an anchor for emergency purposes.

**3.2.2** All anchoring equipment, towing bitts, mooring bollards, fairleads, cleats and eyebolts shall be so constructed and attached to the hull that, in use up to design loads, the watertight integrity of the craft will not be impaired.

**3.2.3** Only anchoring equipment is considered for the purpose of classification. The design of all the out-fittings used for mooring operation and their connection to the deck is out of scope of classification.

#### 3.3 Anchoring

**3.3.1** Crew boats shall be provided with at least one anchor with its associated cable or cable and warp and means of recovery. Every crew boat shall be provided with adequate and safe means for releasing the anchor and its cable and warp.

**3.3.2** Good engineering practice shall be followed in the design of any enclosed space containing the anchor-recovery equipment to ensure that persons using the equipment are not put at risk. Particular care shall be taken with the means of access to such spaces, the walkways, the illumination and protection from the cable and the recovery machinery.

**3.3.3** Adequate arrangements shall be provided for two-way voice communication between the operating compartment and persons engaged in dropping, weighing or releasing the anchor.

**3.3.4** The anchoring arrangements shall be such that any surfaces against which the cable may chafe (for example, hawse pipes and hull obstructions) are designed to prevent the cable from being damaged and fouled. Adequate arrangements shall be provided to secure the anchor under all operational conditions.

**3.3.5** The crew boat shall be protected so as to minimize the possibility of the anchor and cable damaging the structure during normal operation.

#### 3.4 Towing

**3.4.1** Adequate arrangements shall be provided to enable the crew boat to be towed in the worst intended conditions. Where towage is to be from more than one point, a suitable bridle shall be provided.

**3.4.2** The towing arrangements shall be such that any surface against which the towing cable may chafe (for example, fairleads) is of sufficient radius to prevent the cable being damaged when under load.

**3.4.3** The maximum permissible speed at which the crew boat may be towed shall be specified by the Designer.

#### 3.5 Berthing

**3.5.1** Where necessary, suitable fairleads, bitts and mooring ropes shall be provided.

**3.5.2** Adequate storage space for mooring lines shall be provided such that they are readily available and secured against the high relative wind speeds and accelerations which may be experienced.

#### 3.6 Equipment

##### 3.6.1 General

- a) The anchoring equipment required in [3.6.2] is intended for temporary occasional mooring of a crew boat within a harbour or sheltered area when the crew boat is awaiting berth, tide, etc.
- b) The equipment is therefore not designed to hold a crew boat off fully exposed coasts in rough weather or to stop a crew boat which is moving or drifting. In this condition the loads on the anchoring equipment increase to such a degree that its components may be damaged or lost owing to the high energy forces generated, particularly in large crew boats.
- c) For crew boats where frequent anchoring in open sea is expected, the owner's and shipyard's attention is drawn to the fact that anchoring equipment shall be provided in excess of the requirements of these Rules.
- d) For crew boats with an Equipment Number greater than 600, two anchors and two relevant chain cables are required. For such ships engaged in a regular service, the second anchor and its relevant chain cable may be held readily available in one of the home ports.
- e) The anchoring equipment required in [3.6.2] is designed to hold a ship in good holding ground in conditions such as to avoid dragging of the anchor. In poor

holding ground, the holding power of the anchors will be significantly reduced.

- f) The Equipment Numeral (EN) formula for anchoring equipment, as stipulated in [3.6.2], is based on an assumed current speed of 2,5 m/s, wind speed of 25 m/s and a scope of chain cable between 6 and 10, the scope being the ratio between length of chain paid out and water depth.
- g) For small crew boat with a length  $L \leq 25$  m, some partial exemption from the Rules may be accepted especially for what concerns anchor operation; in particular, where proper and safe anchor operation is assured, hand-operated machinery and/or absence of hawse pipe may be accepted.

### 3.6.2 Equipment number

#### a) General

- Each crew boat is to be provided with anchors and relevant stud link chain cables according to its equipment number EN, as stipulated in Tab 5 .
- When two bow anchors are fitted, the mass of each anchor, the diameter and the length of each chain cable are to comply with the requirements of the above-mentioned Table.

#### b) Calculation of equipment number

The equipment number EN is to be calculated as follows:

$$EN = \Delta^{2/3} + 2 \cdot \left[ a \cdot B + \sum_i (b_i \cdot h_i \cdot \sin \theta_i) \right] + 0,1 \cdot A$$

where:

- $\Delta$  : Maximum displacement, in t
- $a$  : Distance, in m, from summer load waterline amidships to the upper deck at side
- $h_i$  : Height, in m, on the centreline of each tier of deck houses having an actual breadth  $b_i$  greater than  $B/4$ , where  $B$  is the breadth, in m, as defined in Sec 3, [2.4]

$\theta_i$  : Angle of inclination aft of each front bulkhead, as shown on Fig 7

$A$  : Area, in  $m^2$ , in profile view of the hull, superstructures and deck houses above the summer load waterline, which is within the rule length of the crew boat defined in Sec 3, [2.4] and with a breadth greater than  $B/4$ .

In the measurement of  $h_i$ , sheer and trim are to be ignored.

If a deck house broader than  $B/4$  is placed on top of another deck house equal to or less than  $B/4$  in breadth, only the widest is to be considered and the narrowest may be ignored.

Windscreens or bulwarks more than 1,5 m in height above the deck at side are to be regarded as parts of superstructures and houses when determining  $h_i$  and  $A$ . The height of hatch coamings may be ignored in the evaluation of  $h_i$  and  $A$ .

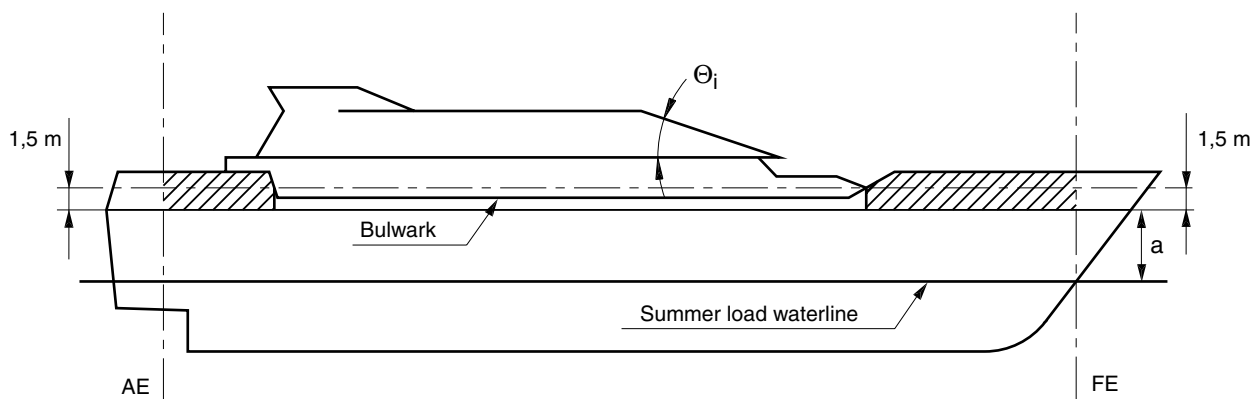
In the calculation of  $A$ , when a bulwark is more than 1,5 m in height, the cross hatched area of Fig 7 is to be considered.

### 3.6.3 Anchors

#### a) Mass of anchors

- Tab 5 indicates the mass of a "high holding power anchor" (HHP) i.e. anchor having a holding power greater than that of an ordinary anchor.
- "Very high holding power anchors" (VHHP), i.e. anchors having a holding power equal to, at least, four times that of an ordinary anchor, may be used.
- The actual mass of each anchor may vary within (+7, -3) per cent of the value shown in the Table.
- The mass of a VHHP anchor is to be not less than 2/3 of the mass required for the HHP anchor it replaces.
- Normally HHP or VHHP anchors are to be used. Possible use of ordinary anchors will be specially considered by the Society.

Figure 7 :



## b) Anchor design

- Anchors are to have appropriate shape and scantlings in compliance with Society requirements and are to be constructed in compliance with Society requirements.
- A high or very high holding power anchor is to be suitable for use on board without any prior adjustment or special placement on the ground.
- For approval and/or acceptance as a high or very high holding power anchor, the anchor is to have a holding power equal, respectively, to at least twice or four times that of an ordinary stockless anchor of the same mass.
- Comparative tests on ordinary stockless anchors are to be carried out at sea and are to provide satisfactory results on various types of seabeds.

Alternatively sea trials by comparison with a previously approved HHP anchor may be accepted as a basis for approval.

Such tests are to be carried out on anchors whose masses are, as far as possible, representative of the full range of sizes proposed for the approval.

At least two anchors of different sizes are to be tested. The mass of the greatest anchor to be approved is not to be in excess of 10 times that of the maximum size tested and the mass of the smallest is to be not less than 0,1 times that of the minimum size tested.

Tests are normally to be carried out by means of a tug, but, alternatively, shore-based tests may be accepted.

The length of the chain cable connected to the tested anchor, having a diameter appropriate to its mass, is to be such that the pull acting on the shank remains practically horizontal. For this purpose a scope of chain cable equal to 10 is deemed normal; however lower values may be accepted.

Three tests are to be carried out for each anchor and type of ground.

The pull is to be measured by means of a dynamometer; measurements based on the bollard pull against propeller's revolutions per minute curve may be accepted instead of dynamometer readings.

Anchor stability and its ease of dragging are to be noted down, whenever possible.

- Upon satisfactory outcome of the above tests, the Society will issue a certificate declaring the compliance of high or very high holding power anchors with its relevant Rules.

**3.6.4 Chain cables**

- Bow anchors are to be used in connection with stud link chain cables whose scantlings and steel grades are to be in accordance with the requirements of the Society.
- Normally grade Q2 or grade Q3 stud link chain cables are to be used with HHP anchors. In case of VHHP anchors, grade Q3 chain cables are to be used.
- Proposal for use of grade Q1 chain cables connected to ordinary anchors will be specially considered by the Society.
- For crew boat with an Equipment Number  $EN \leq 205$ , studless short link chain cables may be used, provided that:
  - steel grade of the studless chain is to be equivalent to the steel grade of the stud chains it replaces, i.e., referring to ISO standard 1834:
    - Class M (4) [grade 400], i.e. grade SL2 as defined in NR 216 "Materials and Welding", in lieu of grade Q2
    - Class P (5) [grade 500], i.e. grade SL3 as defined in NR 216 "Materials and Welding", in lieu of grade Q3
  - equivalence in strength is to be based on proof load (not on breaking load)
  - the studless chain cable meets the requirements of the Society.
- The proof loads PL and breaking loads BL, in kN, required for the studless link chain cables are given by the following formulae, where d, in mm, is the required diameter of grade Q2 and grade Q3 stud chain cables taken from Table [3.6.1]:
  - grade Q2:
 
$$PL_2 = 9,807 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$$

$$BL_2 = 2 \cdot PL_2$$
  - grade Q3:
 
$$PL_3 = 13,73 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$$

$$BL_3 = 2 \cdot PL_3$$
- The method of manufacture of chain cables and the characteristics of the steel used are to be approved by the Society for each manufacturer. The material from which chain cables are manufactured and the completed chain cables themselves are to be tested in accordance with the appropriate requirements.
- Chain cables are to be made of unit lengths ("shots") of 27,5 m minimum joined together by Dee or lugless shackles.

**3.6.5 Steel wire ropes for anchors**

- Steel wire ropes may be used as an alternative to stud link chain cables required in Tab 5 when  $EN \leq 500$ , provided that the following requirements are complied with.
- The length  $L_{swr}$  in m, of the steel wire rope is to be not less than:
  - when  $EN \leq 130$ :
 
$$L_{swr} = L_{ch}$$

- when  $130 < EN \leq 500$ :

$$L_{svr} = L_{ch} \cdot (EN + 850) / 900$$

where  $L_{ch}$  is the length of stud link chain cable required by Tablexxx.

- The effective breaking load of the steel wire rope is to be not less than the required breaking load of the chain cable it replaces.
- The breaking load, in kN, of the chain cable diameters shown between parentheses in Tablexxx may be derived from the following formulae:

- for grade Q2 chain cables:

$$BL = 13,73 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$$

- for grade Q3 chain cables:

$$BL = 19,61 \cdot d^2 \cdot (44 - 0,08 \cdot d) \cdot 10^{-3}$$

where  $d$  is, in mm, the chain cable diameter taken from Tablexxx corresponding respectively to grade Q2 and grade Q3 chain cables.

- A short length of chain cable having scantlings complying with [3.6.4] is to be fitted between the steel wire rope and the bow anchor. The length of this chain part is to be not less than 12,50 m or the distance from the anchor in its stowed position to the windlass, whichever is the lesser.

### 3.6.6 Synthetic fibre ropes for anchors

- Synthetic fibre ropes may be used as an alternative to stud link chain cables required in Tab 5 when  $EN \leq 130$ , provided that the following requirements are complied with.
- Fibre ropes are to be made of polyamide or other equivalent synthetic fibres, excluding polypropylene.
- The length  $L_{sfr}$ , in m, of the synthetic fibre rope is to be not less than:

- when  $EN \leq 60$ :

$$L_{sfr} = L_{ch}$$

- when  $60 < EN \leq 130$ :

$$L_{sfr} = L_{ch} \cdot (EN + 170) / 200$$

where  $L_{ch}$  is the length of stud link chain cable required by Tab 5.

- The effective breaking load  $P_s$ , in kN, of the synthetic fibre rope is to be not less than the following value:

$$P_s = 2,2 \cdot B \cdot L^{8/9}$$

where  $BL$ , in kN, is the required breaking load of the chain cable replaced by the synthetic fibre rope ( $BL$  can be determined by the formulae given in [3.6.5] d)).

- A short length of chain cable complying with [3.6.5] e) is to be fitted between the synthetic fibre rope and the bow anchor.

### 3.6.7 Attachment pieces

Both attachment pieces and connection fittings for chain cables are to be designed and constructed in such a way as to offer the same strength as the chain cable and are to be tested in accordance with the appropriate requirements.

### 3.6.8 Arrangement of anchors and chain cables

The bow anchors, connected to their own chain cables, are to be so stowed as to always be ready for use.

Hawse pipes are to be of a suitable size and so arranged as to create, as far as possible, an easy lead for the chain cables and efficient housing for the anchors.

For this purpose, chafing lips of suitable form with ample lay-up and radius adequate for the size of the chain cable are to be provided at the shell and deck. The shell plating at the hawse pipes is to be reinforced as necessary.

### 3.6.9 Windlass

- The windlass is to be power driven and suitable for the size of chain cable, and is to have the characteristics stated below.

- The windlass is to be fitted in a suitable position in order to ensure an easy lead of the chain cable to and through the hawse pipe; the deck, at the windlass, is to be suitably reinforced.

- The windlass is to be able to supply, for at least 30 minutes, a continuous duty pull  $P_C$ , in N, corresponding to the grade of the chain cables, given by the following formulae:

- for grade Q2 chain cables:

$$P_C = 42,5 \cdot d^2$$

- for grade Q3 chain cables:

$$P_C = 47,5 \cdot d^2$$

where  $d$  is the stud link chain cable diameter of the intended steel grade, in mm.

- The windlass unit prime mover is to provide the necessary temporary overload capacity for breaking out the anchor.

The temporary overload capacity or "short term pull" is to be not less than 1,5 times the continuous duty pull  $P_C$  for at least two minutes.

The speed in this overload period may be lower than the nominal speed specified in [3.6.9] e).

- The nominal speed of the chain cable when hoisting the anchor and cable may be a mean speed only and is to be not less than 0,15 m/s.

The speed is to be measured over two shots of chain cable during the entire trip; the test is to commence with 3 shots (82,5 m) of chain fully submerged, or with the longest practicable submerged chain length where the chain length does not allow 3 shots to be paid out.

- The windlass is to be provided with a brake having sufficient capacity to stop chain cable and anchor when paying out, even in the event of failure of the power supply.

- Windlass and brake not combined with a chain stopper have to be designed to withstand a pull of 80% of the breaking load of the chain cable without any permanent deformation of the stressed parts and without brake slip.

Windlass and brake combined with a chain stopper have to be designed to withstand a pull of 45% of the breaking load of the chain cable.

- h) The stresses on the parts of the windlass, its frame and brake are to be below the yield point of the material used.

The windlass, its frame and the brake are to be efficiently anchored to the deck.

- i) Performance criteria and strength of windlasses are to be verified by means of workshop testing according to the Society Rules.

#### 3.6.10 Chain stopper

A chain stopper is normally to be fitted between the windlass and the hawse pipe in order to relieve the windlass of the pull of the chain cable when the ship is at anchor.

A chain stopper is to be capable of withstanding a pull of 80% of the breaking load of the chain cable; the deck at the chain stopper is to be suitably reinforced.

However, fitting of a chain stopper is not compulsory.

Chain tensioners or lashing devices supporting the weight of the anchor when housed in the anchor pocket are not to be considered as chain stoppers.

Where the windlass is at a distance from the hawse pipe and no chain stopper is fitted, suitable arrangements are to be provided to lead the chain cable to the windlass.

#### 3.6.11 Chain locker

The chain locker is to be of a capacity adequate to stow all chain cable equipment and provide an easy direct lead to the windlass.

Where two anchor lines are fitted, the port and starboard chain cables are to be separated by a steel bulkhead in the locker.

The inboard ends of chain cables are to be secured to the structure by a fastening able to withstand a force not less than 15% nor more than 30% of the breaking load of the chain cable.

In an emergency, the attachments are to be easily released from outside the chain locker.

Where the chain locker is arranged aft of the collision bulkhead, its boundary bulkheads are to be watertight and a drainage system provided.

#### 3.6.12 Anchoring sea trials

The anchoring sea trials are to be carried out on board in the presence of a Society surveyor.

The test is to demonstrate that the windlass complies with the requirements given in [3.6.9] e).

The brake is to be tested during lowering operations.

## 4 Stabilisation means

### 4.1 General

4.1.1 Two different situations are to be considered for the purpose of Sec 3, depending on the main function of the stabilisation system:

Situation 1: The stabilisation system is associated with the safe operation of the crew boat. In that case, the system is covered by the present Rules.

Situation 2: The stabilisation system is only a motion reduction or a ride control system. In such a situation, the system is not covered by the present Rules.

### 4.2 Classification process

4.2.1 For situation 1, the structural design assessment process in scope of classification is given hereafter:

- the following structural parts are reviewed, on basis of design loads and safety criteria indicated by the supplier:
  - structure of the stabilisation devices: foils, trim, tabs or interceptors
  - ship structure supporting the stabilisation devices
- Only power activated items such as foils, trims, tabs or interceptors are assessed. The following parts are reviewed:
  - hydraulic system used for activation of stabilisation system
  - associated electrical devices

4.2.2 For situation 2, the structural design assessment process in scope of classification is given hereafter:

- only the ship strength in way of stabilisation devices is assessed. Ship structure supporting these devices is reviewed, on basis of design loads and safety criteria indicated by the supplier:
- Only possible interferences between hydraulic installation and the safety of the crew boat are of concern. The applicable regulations depend on the location of the hydraulic power pack. The working principles are not checked. However, the hydraulic system documentation is to be submitted.

Table 5 : Equipment

Equipment Number EN		HHP bow anchor		Stud link chain cable for bow anchor		
A < EN ≤ B		Mass of each anchor (kg)	Number of anchors	Total length (m)	Diameter (1)	
A	B				grade Q2 steel (mm)	grade Q3 steel (mm)
19	22	16	1	65,0	(6,0)	(5,5)
22	25	20	1	70,0	(6,5)	(6,0)
25	30	24	1	70,0	(7,0)	(6,5)
30	35	28	1	75,0	(7,5)	(7,0)
35	40	32	1	75,0	(8,0)	(7,5)
40	45	40	1	80,0	(8,5)	(7,5)
45	50	48	1	82,5	(9,0)	(8,0)
50	60	60	1	82,5	(10,0)	(8,5)
60	70	67	1	82,5	11,0	(9,5)
70	80	75	1	110,0	11,0	(10,0)
80	90	90	1	110,0	12,5	11,0
90	100	105	1	110,0	12,5	11,0
100	110	120	1	110,0	14,0	12,5
110	120	135	1	110,0	14,0	12,5
120	130	150	1	110,0	14,0	12,5
130	140	180	1	110,0	16,0	14,0
140	150	195	1	137,5	16,0	14,0
150	175	225	1	137,5	17,5	16,0
175	205	270	1	137,5	17,5	16,0
205	240	315	1	137,5	19,0	17,5
240	280	360	1	137,5	20,5	19,0
280	320	430	1	165,0	22,0	20,5
320	360	495	1	165,0	24,0	22,0
360	400	525	1	165,0	26,0	22,0
400	450	585	1	165,0	26,0	24,0
450	500	675	1	192,5	28,0	26,0
500	550	765	1	192,5	30,0	26,0
550	600	855	1	192,5	32,0	28,0
600	660	900	2	385,0	32,0	30,0
660	720	970	2	385,0	34,0	30,0
720	780	1080	2	440,0	36,0	32,0
780	840	1125	2	440,0	36,0	32,0
840	910	1195	2	440,0	38,0	34,0
910	980	1305	2	440,0	40,0	36,0
980	1060	1440	2	440,0	42,0	36,0
1060	1140	1575	2	440,0	42,0	38,0
1140	1220	1710	2	467,5	44,0	38,0
1220	1300	1845	2	467,5	46,0	40,0

(1) Values of chain cable diameters shown in brackets are given only to allow determination of the corresponding studless chain cable.

# SECTION 5

# MACHINERY

## 1 General

### 1.1 Application

**1.1.1** It is to be referred to Rules for the Classification of Steel Ships, NR470.1 DTM R00 Part C for the subjects which are not dealt with in the present Section, in particular for:

- pressure vessels (see Pt C, Ch 1, Sec 3)
- internal combustion engines (see Pt C, Ch 1, Sec 2)
- reduction gears (see Pt C, Ch 1, Sec 6)
- propellers (see Pt C, Ch 1, Sec 8)
- thickness of pressure piping (see Pt C, Ch 1, Sec 10, 2.2)
- shaft vibrations (see Pt C, Ch 1, Sec 9).

### 1.2 Documents to be submitted

**1.2.1** The following drawings and documents are to be submitted to the Society for approval, in four copies:

- bilge systems
- ballast systems
- air, sounding, overflow piping and devices
- scupper and sanitary discharges
- ventilation systems
- oil fuel piping systems
- lubricating oil piping systems
- oil fuel tanks not forming part of the ship's structure
- engine cooling systems
- compressed air systems
- accessories such as heaters, coolers, pressure vessels
- hydraulic installations and protections against leakage.

The drawings are to be diagrammatic and are to refer to a single system, in order to facilitate their examination.

They are to include:

- service pressures and temperatures
- size and nature of materials for pipes and accessories
- arrangements proposed when remote control is provided for the said installation
- generally, information allowing the verification of the requirements of this Section.

The material characteristics are to be justified by submission of relevant test reports.

### 1.3 Tests - Trials

#### 1.3.1 General

The building and fitting of fluid systems, pumps, pipes and their accessories, as well as other installations referred to in

this chapter are to be attended by a Society's Surveyor, at the Builder's request.

Pneumatic tests are to be avoided whenever possible. When such testing is essential in lieu of hydraulic pressure test, procedure for testing is to be submitted to the Society for acceptance prior to testing.

#### 1.3.2 Testing on board

After assembly onboard, all fittings and accessories being fitted, a hydraulic pressure test is to be carried out for compressed air and oil fuel pipes.

As a rule, the test pressure is not to be less than 1,5 times the service pressure.

#### 1.3.3 Hydraulic tests of oil fuel bunkers, tanks and accessories

The oil fuel bunkers and tanks not forming part of the ship's structure are to be submitted to a hydraulic test under a pressure corresponding to the maximum liquid level in these spaces or in the air or overflow pipes, subject to a minimum of 2,40 m above the top. This minimum height is to be 3,60 m for tanks intended to contain oil fuel having a flash point below 60°C.

Non metallic or metallic flexible pipes and expansion joints are to be tested in accordance with the requirements stated in [1.6.4] e), [1.7.5] a) or [1.9.6], as appropriate.

## 1.4 General requirements applicable to all piping systems

### 1.4.1 Materials

The manufacturer's test certificate for materials for valves and fittings can be accepted in lieu of the Society's materials certificate where the maximum conditions are not beyond those shown in Tab 1.

**Table 1 : Maximum conditions for acceptance of manufacturer's test certificate**

Material	Maximum conditions
Spheroidal or nodular cast iron	DN < 50 and P x DN < 2500
Carbon and low alloy steel	-10°C < t < 300°C and DN < 50, or -10°C < t < 300°C and P x DN < 2500
Cupreous alloy	t < 200°C and DN < 50, or t < 200°C and P x DN < 1500
<b>Note 1:</b> See Pt C, Ch 1, Sec 10, [2.1].	
<b>Note 2:</b> DN = nominal diameter, P = working pressure, t = working temperature.	

#### 1.4.2 Fixing and arrangement of the pipes

Except where otherwise permitted, piping and pumping systems covered by this chapter are to be permanently fixed onboard ship.

Unless otherwise specified, the fluid lines referred to in this chapter are to consist of pipes connected to the ship's structure by means of collars or similar devices.

As far as possible, pipes are not to pass near switchboards or other electrical apparatuses. If this requirement is impossible to satisfy, gutterways or masks are to be provided wherever deemed necessary to prevent projections of liquid on live parts.

These provisions also apply to the exhaust pipes of internal combustion engines.

#### 1.4.3 Protection of pipes

Pipes are to be efficiently protected against corrosion particularly in their most exposed parts, either by selection of their constituent materials, or by an appropriate coating or treatment.

#### 1.4.4 Accessories

Locks, valves and other accessories are generally to be so placed that they are easily visible and accessible for manoeuvring, control and maintenance.

### 1.5 Sea inlets and ship side valves

#### 1.5.1 Valves

All sea inlet and outlet pipes are to be provided with valves fixed:

- directly on the plating, or
- on steel chests built on the plating, or
- on strong distance pieces as short as possible which may be welded to the plating.

#### 1.5.2 Strainers

Sea inlets are to be fitted with strainers. The flow section through each strainer is not to be less than twice the total section of the suction pipes connected to the said inlet.

#### 1.5.3 Materials

The valves on sea inlets and overboard discharges are to be of steel or appropriate non-brittle material.

Similar provisions apply to distance pieces connecting the valves to the shell plating.

#### 1.5.4 Protection against corrosion

Efficient arrangements such as the fitting of zinc anodes are to be made in order to protect the steel parts of sea inlets and discharges against corrosion.

### 1.6 Non-metallic rigid pipes

#### 1.6.1 General

The Society may permit the use of rigid pipes made of plastics in lieu of metallic pipes in the conditions specified in [1.6.2], [1.6.3] and [1.6.4].

These requirements apply to thermoplastic materials but, where appropriate, may also be applied to pipes manufactured in fibre reinforced thermosetting resins.

For every application, characteristics of the proposed plastics are to be given to the Society, namely:

- the chemical composition
- the physical and mechanical characteristics in function of the temperature
- the fire properties
- eventually, the resistance to the various products likely to come into contact with those plastics.

#### 1.6.2 Use of plastic pipes

pipes made of plastics are permitted, as a general rule, for:

- scupper and sanitary discharge pipes
- ballast pipes except for the parts passing through engine rooms, dangerous spaces and oil fuel bunkers or located between pumps and their suctions and discharges
- individual bilge pipes for small compartments such as chain lockers.

For other pipes such as air and sounding pipes of compartments not intended to contain oil fuel, the Society may accept the use of plastics subject to an examination of the relevant drawings.

Pipes made of plastics may be used for fluid systems not covered by the classification provided the requirements given in [1.6.3] are complied with.

Pipes made of plastics are not to be used where they are subject to temperature above 60°C or below 0°C.

The use at a higher temperature for particular applications is subject to special examination.

Any proposed service for plastic pipes not mentioned above is to be submitted to the Society for special consideration.

#### 1.6.3 Intactness of watertight subdivision and fire divisions

As a rule, pipes made of plastics cannot pass through watertight bulkheads.

If, however, such a passage cannot be avoided, arrangements are to be made in order to ensure the integrity of the subdivision in case of pipe breakage. Such arrangements are to be submitted to the Society.

The use of pipes made of plastics is generally to be avoided wherever the destruction of these pipes in case of fire would compromise the intactness of subdivision or the safety of the ship.

Where pipes made of plastics are to pass through fire divisions, the arrangements taken to ensure the fire integrity of these divisions are to be submitted to the Society.

#### 1.6.4 Design and construction

Pipes and fittings are to be of a robust construction and are to comply with the requirements of such national standards as may be consistent with their intended use.

Particulars of scantlings and joints are to be submitted for examination.

All pipes are to be adequately but freely supported. Suitable provision for expansion and contraction is to be made in each range of pipes to allow for important clearance between pipes made of plastics and steel structures, in con-

sideration of the difference between their individual coefficient of thermal expansion.

All fittings and branches are to be suitable for the intended service and are to have joints of cemented, flanged or other approved types.

The bursting pressure of pipes, fittings and joints made of plastics, at their service temperature, is not to be less than 4 times their maximum service pressure, with a minimum of 5 bar.

After completion, pipes and fittings are to be subjected to a hydraulic pressure test, to be applied during at least 5 minutes under a pressure not less than 1,5 times the service pressure.

## 1.7 Non-metallic flexible pipes and expansion joints

### 1.7.1 General

The Society may permit the use of flexible pipes and expansion joints containing non-metallic parts in the conditions stated in [1.7.2] to [1.7.5].

The drawings of flexible pipes and expansion joints are to be submitted to the Society.

These drawings are to show, in particular:

- the chemical and physical properties of the constituent materials
- the type of the connection and the nature of their constituent materials
- the type of junction between connections and pipes or expansion joints.

The approval of flexible pipes and expansion joints is to be subject to the execution of the type tests defined in [1.7.4].

Any flexible pipe or expansion joint to be used at a temperature below the ambient temperature is to be given special consideration.

### 1.7.2 Materials - Construction

Flexible pipes and expansion joints are to be made of materials resisting to marine environment and to the fluid they are to convey.

Flexible pipes and expansion joints are to be built so as to withstand:

- externally the hydrocarbons
- internal pressure
- vibrations
- pressure impulses, when appropriate.

Unless otherwise justified, flexible pipes intended to convey oil or fuel are to be fire-resistant. Where a protective lining is provided for this purpose, it is to be impervious to hydrocarbons and to hydrocarbon vapours.

Flexible pipes intended to convey gaseous fluid at a pressure higher than 10 bar, and as a general rule, those conveying oil or fuel, are to be fitted with a metallic braid.

As a general rule, flexible pipes are to be fitted with crimped connections or equivalent. However, for water pipes subject to a pressure not exceeding 5 bar, as well as for scavenge air and supercharge air lines of internal com-

bustion engines, clips made of galvanised steel or corrosion-resistant material may be used.

The bursting pressure of flexible pipes and expansion joints at their service temperature is not to be less than 4 times their maximum service pressure, with a minimum of 20 bar. Dispensations to this requirement may be granted for expansion joints of big diameter used on sea water lines.

The junctions of flexible pipes and expansion joints to their connections are to withstand a pressure at least equal to the bursting pressure.

### 1.7.3 Conditions of use

The use of flexible pipes and expansion joints is to be as limited as practicable.

The use of flexible pipes and expansion joints is not permitted between the plating and valves defined in [1.5.1].

The location of flexible pipes and expansion joints is to be clearly shown on the piping drawings submitted to the Society.

Flexible pipes and expansion joints are to be as short as possible.

The radius of curvature of flexible pipes is not to be less than the minimum recommended by the manufacturer.

Isolating valves are to be provided permitting the isolation of flexible pipes intended to convey fuel, oil or compressed air.

Flexible pipes and expansion joints are to be so arranged as to be accessible at all times.

### 1.7.4 Type-tests

In view of approval, the following is to be carried out on a flexible pipe or an expansion joint of each type and each size:

- bursting test
- fire-resistance test in the cases mentioned in [1.7.2]
- when required, vibration tests, corrosion resistance tests, ageing tests and pressure impulse tests.

The flexible pipes or expansion joints subjected to the tests are to be fitted with their connections.

The fire-resistance test is to be carried out in the conditions hereafter; other test methods may be applied after special examination.

The flexible pipe is to be subjected to fire for 30 minutes at a temperature of 800°C, while water at the maximum service pressure is circulated inside the pipe; the temperature of the water at the outlets is not to be less than 80°C. No leak is to be recorded during and after the test.

Flexible pipes or expansion joints granted with a type approval certificate issued by the Society for the intended conditions of use are exempted from type-tests.

### 1.7.5 Hydraulic tests

Each flexible pipe or expansion joint, together with its connections, is to undergo a hydraulic test under a pressure at least equal to twice the maximum service pressure, subject to a minimum of 10 bar.

During the test, the pipe or expansion joint is to be repeatedly deformed from its geometrical axis.

### 1.7.6 Marking

Each flexible pipe or expansion joint is to be stencilled or otherwise marked with its specified maximum service pressure and, when used in other than ambient temperature, its maximum or minimum service temperature or both.

### 1.7.7 Periodical replacement - Spare parts

Flexible pipes or expansion joints are to be periodically replaced according to the periodicity depending on their types.

A spare is recommended for each type of flexible pipe or expansion joint the failure of which could impair the operation of main engines, that of auxiliary engines for essential services or the safety of the ship.

## 1.8 Metallic flexible pipes and joints

**1.8.1** Metallic flexible pipes and joints are to comply with the requirements stated in [1.7], as far as applicable.

Fire-resistance tests need not be carried out.

## 1.9 Non-metallic hoses

### 1.9.1 General

The Society may permit the use of non-metallic hoses in the conditions stated in [1.9.2] to [1.9.4].

Attention is drawn to the fact that the non-metallic hoses in relation with this sub-article may be used instead of metallic or non-metallic rigid pipes in the conditions stated in [1.9.3]. No confusions are to be made with the flexible pipes and expansion joints which are covered by [1.7].

The drawings of the non-metallic hoses are to be submitted to the Society. These drawings are to indicate in particular:

- the manufacturer and the type
- the composition
- the physical and mechanical characteristics according to the temperature
- the characteristics of inflammability and the fire resistance
- eventually the resistance to the various products they are likely to come into contact with
- the diameter and thickness
- the type of junctions with the other pipes and fittings.

Non-metallic hoses are to undergo type-tests defined in [1.9.5].

### 1.9.2 Design - Construction

Non-metallic hoses are to be made of materials resisting to marine environment and to the fluid they are to convey.

Non-metallic hoses are to be designed so as to withstand:

- externally to hydrocarbons
- to internal pressure
- to vibrations.

Non-metallic hoses intended to convey oil or fuel are to be fire-resistant. Where a protective lining is provided for this purpose, it is to be impervious to hydrocarbons and hydrocarbon vapours.

If non-metallic hoses are intended to be fitted at pump suction, in particular bilge pumps, they are to be so designed

as to avoid any risk of collapsing due to the internal depression of the pipes.

Clips made of corrosion-resistant material may be used for the junction of non-metallic hoses, with at least two clips at each end, except for oil and fuel circuits where crimped connections are to be used.

The bursting pressure of non-metallic hoses is not to be less than four times their maximum service pressure.

### 1.9.3 Conditions of use

Non-metallic hoses may be used for the following piping circuits only:

- bilge
- ballast
- sea water or fresh water cooling
- lub oil or fuel oil transfer ( $P \leq 7$  bar,  $T \leq 60^\circ\text{C}$ )
- compressed air ( $P \leq 16$  bar)
- venting air
- scupper
- sanitary discharges
- non-essential services.

The position of the non-metallic hoses is to be clearly shown on the piping drawings submitted to the Society.

Isolating valves are to be provided permitting the isolation of flexible pipes intended to convey fuel, oil or compressed air.

Non-metallic hoses are not to be used between the ship's side and the valves mentioned in [1.5.1].

Non-metallic hoses are not to be used for the part of bilge piping circuits going through compartments intended to contain oil fuel.

### 1.9.4 Installation

Non-metallic hoses are to be so arranged as to be easily accessible.

They have to be supported by means of collars or similar devices, so that the hoses and the junctions are not submitted to excessive stresses in all the normal service conditions.

The parts of non-metallic hoses which are likely to undergo shocks or frictions are to be adequately protected by means of shield or appropriate sleeve.

### 1.9.5 Type-tests

Each type of non-metallic hose is to undergo:

- a bursting test
- an external hydrocarbon resistance test
- a fire resistance test in the cases mentioned in [1.9.2]
- a collapse test in the cases mentioned in [1.9.2]
- eventually vibration and ageing tests.

The tests are to be carried out on hoses having a significant length and fitted with connections as stated [1.9.2].

The fire resistance test is to be carried out in the following conditions; other test methods may apply after special examination.

The hose is to be submitted to fire for 30 minutes at a temperature of 800°C, while water at the maximum service pressure is circulated inside the hose; the temperature of the water at the outlets is not to be less than 80°C. No leak is to be recorded during and after the test.

Non-metallic hoses granted with a type approval certificate issued by the Society for the intended conditions of use are exempted from type-tests.

### 1.9.6 Hydraulic tests

Each hose, together with its connections, is to undergo a hydraulic test under a pressure at least equal to 1,5 times the maximum service pressure.

## 2 Bilge system

### 2.1 General

#### 2.1.1 Principle

All ships are to be provided with efficient means for pumping and draining any watertight space with at least one suction pipe when the ship is on an even keel and either is upright or has a list of up to 5°.

#### 2.1.2 Independence of the lines

As a general rule, bilge lines are to be distinct from the other lines of the ship.

However, this requirement need not be applied to pipes located between collecting boxes and pump suction or between pumps and overboard discharges.

#### 2.1.3 Intactness of watertight subdivision

The lines and accessories are to be so arranged as to prevent intercommunication of compartments which are to remain segregated from each other or the accidental connection of these compartments directly to the sea.

#### 2.1.4 Bilge main

A bilge main is to be provided for draining the different compartments for ships which length is greater or equal to 12 m.

#### 2.1.5 Number and distribution of suction

At least two bilge suction are to be provided for draining the propulsion engine room. At least one of these suction is to be connected directly to a bilge pump.

The suction are to be located at the lowest points of the compartment.

Additional suction may be required if the flow of water towards the suction is disturbed by irregularities of the bottom.

At least one bilge suction is to be provided in each compartment located between two watertight bulkheads.

### 2.2 Pumps and ejectors

#### 2.2.1 Pumps

At least two power bilge pumps are to be provided; one of these pumps may be driven by a main propulsive engine.

The Society may permit, after special consideration, that one of the pumps be replaced by an ejector.

For ships the length of which is greater or equal to 12 m, the bilge pumps are to be connected to the bilge main mentioned in [2.1.4].

For ships the length of which is less than 12 m, the Society may permit, after special consideration, that one of bilge pumps be a fixed hand pump.

Small compartments may be drained by means of portable or fixed hand pumps.

#### 2.2.2 Ejectors

Where an ejector is used in lieu of a driven pump, its suction capacity is not to be less than the required capacity of the pump it replaces.

#### 2.2.3 Capacity of the pumps

The capacity of the bilge pumps is to be such that a speed of water not less than 1,22 m/s may be obtained in the bilge main the diameter of which is given in [2.3.1]. The capacity of each pump is therefore not to be less than:

$$Q = 0,00345 d_1^2$$

where:

Q : Minimum capacity of each pump, in m<sup>3</sup>/h

d<sub>1</sub> : Internal diameter, in mm, of the bilge main as defined in [2.3.1].

### 2.3 Size of bilge pipes

#### 2.3.1 Bilge main

The internal diameter, in mm, of the bilge main, is to be of the commercial size nearest to the diameter given in the following formula, in mm:

$$d_1 = 1,68\sqrt{L(B+C)} + 25$$

in addition, d<sub>1</sub> is not to be less than 35 mm,

where:

L : Rule length of the ship, in m, defined in Sec 3

B : Breadth of the ship, in m, defined in Sec 3

C : Moulded depth of the ship, in m, at the free-board deck.

#### 2.3.2 Suction in holds and machinery spaces

The internal diameter, in mm, of bilge pipes situated between collecting boxes and suction in holds and machinery spaces, is to be of the commercial size nearest to the diameter given by the following formula, in mm:

$$d_2 = 2,16\sqrt{L_1(B+C)} + 25$$

in addition, d<sub>2</sub> is not to be less than 35 mm,

where:

B, C : Dimensions having the same meaning as in [2.3.1]

L<sub>1</sub> : Length of the compartment, in m.

## 2.4 Arrangement of bilge lines and their accessories

### 2.4.1 Passage of pipes through certain compartments

If not contained in pipe tunnels, the part of bilge pipes passing through compartments intended to contain oil fuel are to have reinforced thickness and are to consist of a single piece. These pipes are to be provided with non-return valves at their ends in the holds.

### 2.4.2 Passage through watertight bulkheads

No bilge cock or similar device is to be fitted on the collision bulkhead.

The fitting of bilge cocks or similar devices on other watertight bulkheads is to be avoided as far as possible. However, where such accessories are provided, they are to be accessible at any time and capable of being closed from positions above the deck. An indication is to be provided to show whether these valves are open or close.

### 2.4.3 Non-return valves

Accessories are to be provided to prevent intercommunication of compartments or lines which are to remain segregated from each other. For this purpose, non-return valves or similar devices are to be fitted, namely on the pipe connections to bilge distribution boxes or to the alternative cocks, if any.

### 2.4.4 Strainers and mud boxes

Strainers and mud boxes are to be fitted on bilge lines wherever they are necessary.

## 3 Other hull piping

### 3.1 Air pipes

#### 3.1.1 General

Air pipes are to be fitted to all compartments intended to contain liquid or which are not fitted with alternative ventilation arrangements.

These air pipes are to be so arranged as to be self-draining when the ship is on an even keel.

#### 3.1.2 Number and position of air pipes

Air pipes are to be so arranged and the upper part of compartments so designed that air or gas likely to accumulate in the said compartments can freely evacuate.

When only one air pipe is provided, it is not to be used as filling pipe.

#### 3.1.3 Tank air pipes

Air pipes of compartments likely to contain liquid hydrocarbons, cofferdams or any capacity likely to be pumped up are to be led out, at a sufficient height above the deck.

Air pipes of all compartments which can be run up from the sea are to be led to above the deck.

Moreover, air pipes of compartments containing liquid hydrocarbons are not to be led to a place where danger could be the consequence of the evacuation of hydrocar-

bons or hydrocarbon vapours through these openings. They are to be fitted with gauze screens.

Air pipes of lubricating oil tanks and bunkers may be led to the machinery spaces, provided that in case of overflow the oil cannot come into contact with electrical apparatus or with surfaces likely to be at a high temperature.

#### 3.1.4 Open ends of air pipes

Efficient, permanently attached devices are to be provided permitting, should the necessity arise, to close the upper openings of air pipes in order to prevent any accidental entry of water into the spaces concerned.

Where the tank venting system is not of an automatic type approved by the Society, provision is to be made for relieving vacuum when the tanks are being pumped out, and for this purpose a hole of about 10 mm in diameter in the bend of the air pipe, or at a suitable position in the closing device, is acceptable.

#### 3.1.5 Construction

In each compartment likely to be pumped up, and where no overflow pipe is provided, the total cross-sectional area of air pipes is not to be less than the cross-sectional area of the corresponding filling pipes.

## 3.2 Sounding and level gauging devices

### 3.2.1 General

Arrangements are to be made for sounding the tanks intended to contain liquid as well as all the compartments which are not readily accessible at all times.

### 3.2.2 Upper ends of sounding pipes

As a general rule, the sounding pipes are to end above the deck in easily accessible places and are to be fitted with efficient closing appliances.

However, in machinery spaces, when this requirement cannot be met, short sounding pipes may be used which are to lead to readily accessible positions above the floor and fitted with efficient closing appliances. When such sounding pipes are used for oil fuel or lubricating oil tanks, they are to be fitted with automatic self closing caps and they are not to end close to electric motors or switchboards and are to be fitted with automatic closing devices.

### 3.2.3 Construction

Internal diameter of sounding pipes is not to be less than 30 mm.

Doubling plates are to be placed under the lower ends of sounding pipes in order to prevent damage to the hull.

### 3.2.4 Level-indicator systems

Level-indicator systems are to be of robust construction and suitably protected.

When used on fuel tanks or bunkers, level-indicator systems are to meet the requirements stated in [4.1.4].

## 3.3 Ventilation

**3.3.1** Adequate ventilation is to be provided for spaces containing engines, boilers or other heat generating appara-

tuses, as well as for spaces where flammable vapours are likely to accumulate.

**3.3.2** Ventilators serving the machinery spaces are to be capable of being closed in case of fire, from outside the said spaces. Skylights and other openings serving these spaces are to meet the requirements stated in Sec 7, [2.1.4].

**3.3.3** Ventilation of spaces containing propulsive plant and its auxiliaries is to be mechanical.

**3.3.4** Mechanical ventilating fans are to be capable of being stopped from outside the space supplied by these ventilating fans.

## 4 Oil fuel systems

### 4.1 General

#### 4.1.1 Scope

The requirements stated in [4.1] and [4.2] are applicable to oil fuel systems for the service of propulsion engines and auxiliary machines. The flash point of the oil fuel used, determined by means of closed cup test, is not to be lower than 60°C.

The use for propulsion engines and auxiliary machine of oil fuel having a flash point lower than 60°C is subject to a special examination by the Society.

#### 4.1.2 Pumps controls

The power supply to oil fuel transfer pumps and to other pumps of the oil fuel system as well as to oil fuel separators is to be capable of being stopped from an always accessible place in the event of fire within the compartment where these equipment are located.

#### 4.1.3 Drip-trays and gutterways

Drip-trays or gutterways with appropriate discharge devices are to be fitted:

- under pumps, valves and filters
- under oil fuel tanks and bunkers which are not part of the ship's structure, as well as
- under all the accessories subject to oil fuel leakage.

#### 4.1.4 Level indicators

Gauge cocks for checking the level in the tanks are not to be used.

The glasses of any level indicator fitted on such tanks are to be made of heat-resistant material and are to be efficiently protected against shock. Such level indicators are to be fitted with self-closing cocks at their lower end as well as at their upper end if the latter is below the maximum liquid level.

Where the fuel transfer system does not include power pumps but only hand pumps, the valves to be provided at the lower end of level-indicators for fuel tanks, with the exception of daily service tanks, need not to be of the self-closing type. These valves are however to be readily accessible and instruction plates are to be fitted near these valves specifying that they are to be maintained closed except during transfer operations.

## 4.2 Oil fuel tanks and bunkers

### 4.2.1 Scantlings

The scantlings of oil fuel bunkers and tanks forming part of the ship's structure are to comply with the requirements stated in Sec 3.

### 4.2.2 Location of oil fuel tanks and bunkers

Location of oil fuel tanks and bunkers is to be chosen in a way to avoid any abnormal rise in temperature in these capacities.

The use of free standing oil fuel tanks is not permitted in high fire risk areas.

### 4.2.3 Suctions and discharges to oil fuel tanks and bunkers

All suction pipes to oil fuel tanks and bunkers, including those in double bottom, are to be provided with valves.

In the case of bunkers and oil fuel storage, settling or daily service tanks other than those in the double bottom, the valves are to be fitted directly on the plating of these bunkers and tanks and are to be so arranged that they can always be remotely closed in the event of fire taking place in the compartment where they are located.

Where the oil fuel transfer installation does not include power pumps but only hand pumps, the suction valves to oil fuel tanks and bunkers, with the exception of daily service tanks, need not to be provided with remote controls. These valves are however to be readily accessible and instruction plates are to be fitted in their vicinity specifying that they are to be maintained closed except during transfer operations.

Where the discharge pipes to oil fuel bunkers and tanks are not led to the upper part of the said bunkers and tanks, they are to be provided with non-return valves at their ends.

### 4.2.4 Drains

Daily service tanks are to be provided with drains permitting the evacuation of water and impurities likely to accumulate in the lower part of these tanks.

These drains are to be fitted with self-closing valves or cocks.

### 4.2.5 Materials - Tests

The use of materials other than steel for fuel bunkers and tanks which are not part of the ship's structure is specially examined.

Oil fuel tanks and bunkers are to be tested under the conditions specified in [1.3.3].

## 4.3 Transfer pipes

### 4.3.1 Arrangement of the transfer system

The transfer system together with its accessories are to be so arranged that oil fuel cannot enter compartments the structure of which does not allow them to be filled with oil fuel or compartments intended to contain drinking water.

### 4.3.2 Transfer pumps

Where oil fuel is transferred by means of a power pump, arrangements are to be made so that oil fuel may be

pumped, in the event of a damage to this pump, by means of a stand-by pump, which can be a hand pump.

#### 4.3.3 Passage through particular compartments

No fuel pipes are to pass through fresh water tanks and no fresh water pipes are to pass through fuel oil tanks.

### 4.4 Oil fuel supply to engines

**4.4.1** The suctions of engine fuel pumps are to be so arranged as to prevent the suction of gathered water and sludge likely to accumulate after decanting at the lower part of service tanks.

**4.4.2** Two filters, or similar devices, are to be provided and so arranged that one of the filters can be overhauled while the other is in use.

### 4.5 Materials - Construction

**4.5.1** Low-pressure oil fuel pipes are generally to be made of steel. Where the internal diameter of these pipes does not exceed 25 mm, they may be of seamless copper or copper-alloy unless they pass through oil fuel tanks.

**4.5.2** Transfer oil fuel pipes may be of non metallic hoses in the conditions stated in [1.9].

**4.5.3** The pipes are to be connected by means of close-fitting flanges or other devices deemed equivalent for the application considered. The materials of the joints are to be impervious to liquid hydrocarbons.

## 5 Other systems of machinery

### 5.1 Lubricating oil systems

#### 5.1.1 General

The lubricating oil systems are to be so arranged as to operate satisfactorily when the ship is inclined from the normal position to angles of up to 15° transversely or 5° longitudinally, or when rolling to angles of up to 22°30' or pitching up to 7°30'.

Lubricating oil pipes are to be independent of any other fluid system.

#### 5.1.2 Lubricating pumps

Main engines are normally to be provided with at least two power lubricating pumps. Where the installation includes at least two propulsive units, the Society may permit that only one pump be provided for each propulsive unit.

Where the power per engine does not exceed 370 kW or when the ratio of the power per engine expressed in kW to the rotating speed in revolutions per minute does not exceed 0,75, the Society may permit that one of the pumps mentioned in item a) be a spare pump ready to be connected to the lubricating oil system. Provision is to be made for the corresponding disassembling and reassembling operations to be carried out on board in a time as short as possible.

#### 5.1.3 Filters

In forced lubrication systems, a device is to be fitted which efficiently filters the lubricating oil in the circuit. The filters provided for this purpose are to be so arranged that they can be easily cleaned without stopping the lubrication of the machines.

#### 5.1.4 Safety devices

Lubricating oil systems for propulsive engines are to be provided with an alarm device giving audible warning in the event of an appreciable reduction of the oil pressure.

### 5.2 Engine cooling systems

#### 5.2.1 Principle

a) Provision is to be made so that the cooling of main engines and of lubricating oil or fresh water coolers for these engines can be suitably ensured in all normal operating conditions.

b) Generally, cooling water to propulsion engines and to lubricating oil or fresh water coolers is to be capable of being supplied by two separate means.

The second means for engine cooling may consist of a satisfactory connection to a general service pump of sufficient capacity.

Where the power per engine does not exceed 370 kW or when the ratio of the power per engine expressed in kW to the rotating speed in revolutions per minute does not exceed 0,75, the Society may permit that the second means be a spare pump ready to be connected to the cooling system. Provision is to be made for the corresponding disassembling and reassembling operations to be carried out on board in a time as short as possible.

c) Engine cooling systems in ships having several propulsion engines are to be given special consideration by the Society.

#### 5.2.2 Fresh water cooling system

Where the engines are cooled by fresh water, the second means stated in [5.2.1] b) may be omitted if a connection is fitted from the fresh water system to a suitable salt water system.

#### 5.2.3 Cooling pumps

The pumps which may be connected to cooling systems may be either independent or driven by the machine they serve.

Relief valves are to be fitted on the discharge of cooling pumps driven by main engines, except for centrifugal type pumps.

#### 5.2.4 Sea inlets

Not less than two sea inlets are to be provided for the engine cooling system. These sea inlets are to be distinct for the two means of cooling given in [5.2.1] b), but they may be cross connected by a cross pipe.

These sea inlets are to be low inlets and one of them may be that of the ballast pump or of the general service pump. A sea-inlet is considered as low provided it remains submerged under all normal navigating conditions.

### 5.2.5 Filters

Where propulsive engines are directly cooled by sea water, either in normal service or in emergency, filters are to be fitted on the suction of cooling pumps.

### 5.2.6 Operating control

Means are to be provided for controlling the temperature and the water circulation of each engine.

### 5.2.7 Materials

The materials used for cooling systems are to be such as to limit the effects of galvanic corrosion and erosion considering the circulation speeds adopted.

## 5.3 Other systems of machinery

### 5.3.1 Starting compressed air systems

The compressed air system for starting main engines is to be so arranged that it is possible to ensure the initial charge of the air receiver(s). A hand compressor may be used for this purpose. Alternatively a compressor with a hand started prime mover may be used.

The prescription a) can be considered as fulfilled when the starting of the main engines is conducted, normally or under emergency, by starting devices such as fuses, inertia starters or other means deemed equivalent.

When only one air compressor is used for filling the air receivers, there are to be at least two air receivers.

The main engine air receivers are to have a total capacity sufficient to provide, without replenishment:

- 12 consecutive starts of the reversible type engines
- 6 consecutive starts of the non-reversible type engines.

### 5.3.2 Accessories for compressed air systems

The receivers, compressors, pipes and other accessories of the compressed air systems are to be fitted with adequate devices to avoid any appreciable overpressure in any point of the system.

### 5.3.3 Arrangement of compressed air systems

Efficient oil and water separators are to be provided on the discharge of compressors.

Non-return valves or other safety devices are to be provided on the starting air mains of each engine.

## 5.4 Exhaust gas systems

### 5.4.1 Hull outlet

Where exhaust gas pipes are led overboard close to the load water line, arrangements are to be made to prevent any entry of water in the ship or in the engines while in normal operation.

In that respect, properly designed goose neck can be considered.

### 5.4.2 Cooling and lagging

The exhaust gas pipes and silencers which pass through spaces of the ship where a temperature rise might be dangerous are to be efficiently cooled or lagged.

### 5.4.3 Water-cooled exhaust gas pipes

When water-cooled exhaust gas pipes are used, a high temperature alarm must be fitted after the water injection device. Alternatively, a low sea water flow rate alarm may be fitted.

## 5.5 Hydraulic installations

### 5.5.1 General

Installations using flammable oils are to be given special consideration by the Society.

### 5.5.2 Safety and monitoring devices

Whenever practicable, the hydraulic power units are to be located outside the main engine or boiler rooms. Shields or similar devices are to be provided around the hydraulic power units in order to avoid accidental oil spray or oil mist on heated surfaces which may ignite oil.

## 6 Steering gear

### 6.1 General

6.1.1 The steering gears have to comply with the requirements of:

- Pt C, Ch 1, Sec 11, 1, 2 and 4
- Sec 6, [2.7.3]
- Sub-article [1.7].

## 7 Propelling and auxiliary machinery

### 7.1 Shafting

#### 7.1.1 Propeller shaft diameter

The diameter of the shaft going through the stern tube is not to be less than the diameter  $d$ , in mm, given by the following formula:

$$d = K (F / N)^{1/3}$$

where:

- F : Brake power, in kW  
 N : Shaft revolutions per minute  
 K : Coefficient having the values given in Tab 2.

Furthermore, the shaft diameter is not to be less than 25 mm for carbon steel or carbon manganese steel, and 20 mm for the other materials listed in Tab 2.

The use of materials other than those included in Tab 2 is to be subject to special examination.

#### 7.1.2 Intermediate shaft diameter

The diameter, in mm, of the intermediate shafts is not to be less than :

$$d' = 0,8 K (F / N)^{1/3}$$

where F, N and K are defined in [7.1.1].

### 7.2 Shafting accessories

#### 7.2.1 Coupling bolts

The diameter of coupling bolts at the joining faces of the couplings is to be not less than the diameter  $D_b$  given, in

mm, by the following formula, for intermediate, propeller and thrust shafts:

$$D_b = 11 \left( \frac{F}{n \cdot r \cdot R_b \cdot N} \right)^{1/2} 10^3$$

where:

- n : Number of bolts in the coupling  
 r : Radius of the pitch circle of the bolts, in mm  
 R<sub>b</sub> : Ultimate tensile strength of the bolt metal, in N/mm<sup>2</sup>.

F and N have the meanings given in [7.1.1].

### 7.2.2 Shaft liners

The thickness of bronze shaft liners in way of the bushes and stern gland is to be not less than the thickness e, in mm, given by the following formula:

$$e = \frac{d + 230}{32}$$

where:

- d : Actual diameter of the propeller shaft, in mm.

### 7.2.3 Stern bearing

#### a) Water lubrication

The length of the after bearing of the propeller shaft is not to be less than 2 times the rule diameter of the propeller shaft, furthermore the bearing is to be made of a type approved synthetic material.

#### b) Oil lubrication

The length of the after bearing of the propeller shaft is not to be less than 2 times the rule diameter of the propeller shaft, furthermore:

- the bearing material is to be of the antifrictional type
- the oil gland is to be type approved.

#### c) Other arrangements

The other arrangements beside those defined in items a) and b) are to be given special consideration. The length of the after bearing of the propeller shaft is not to be less than 3,5 times the rule diameter of the propeller shaft.

### 7.2.4 Sealing gland

The sealing glands must be readily accessible, for inspection or replacement.

The sealing glands are to be periodically inspected.

The temporary actions to be taken in case of accidental failure of a main component, as well as the inspection periodicity and the replacement schedule of parts subject to wear or deterioration, are to be specified.

The wear strength of non-metallic parts is to be established, either by satisfactory operations, or by relevant tests.

An easy to fit emergency device may be accepted.

**Table 2 : Values of coefficient K**

Material	Indicative chemical composition (%)	R <sub>eH</sub> mini N/mm <sup>2</sup>	R <sub>m</sub> mini N/mm <sup>2</sup>	K
Carbon and carbon manganese steel	C: 0,16 - 0,25 Si ≤ 0,45 S ≤ 0,040 P ≤ 0,040	200	400	126
Austenitic stainless steel (type 316)	C ≤ 0,080 Mn ≤ 2,0 Si ≤ 1,0 Cr: 16,0 - 18,0 Ni: 11,0 - 13,0 Mo: 2,0 - 3,0	175	470	91
Manganese bronze	Cu: 52 - 62 Pb ≤ 0,5 Mn ≤ 2,0 Fe ≤ 1,2 Zn remainder	245	510	92
Martensitic stainless steel (type 431)	C ≤ 0,20 Si: 0,80 Mn: 1,0 Ni: 2,0 - 3,0 Cr: 15,0 - 18,0	675	850	88
Ni-Al bronze	Ni: 4,0 - 6,0 Al: 7,0 - 11,0 Fe: 2,0 - 6,0 Mn ≤ 2,0 Cu remainder	390	740	85
Nickel-copper alloy (Monel 400)	Ni: 63 - 70 Fe ≤ 2,0 Mn ≤ 1,5 C ≤ 0,25 Cu remainder	350	550	85
Nickel-copper alloy (Monel K 500)	Ni: 63 - 70 Al: 2,0 - 4,0 Fe ≤ 2,0 Mn ≤ 1,5 C ≤ 0,25 Cu remainder	690	960	71

## SECTION 6

## ELECTRICAL INSTALLATIONS

### 1 General

#### 1.1 General requirements

##### 1.1.1 Documents to be submitted

The following drawings and documents are to be submitted to the Society for approval, in four copies:

- general single line diagram of the main power, main lighting and emergency distribution networks
- single line diagrams of the main generators switchboard and possible distribution boards
- drawing showing the location of the main electrical equipment (generators, batteries, battery chargers, switchboards, etc.).

These drawings or documents are to be drafted according to normal practice and are to specify all factors permitting an accurate study of the installation within the requirements of the present section, and in particular:

- the type and characteristics of the generators
- the type and size of the conductors
- the type and characteristics of protection devices and control devices (fuses, contactors, switches, circuit-breakers).

In addition, the Society reserves the right to request any other document or piece of information deemed necessary, considering the nature or the importance of the installations (electrical balance, calculation of the capacity of the batteries, etc.).

##### 1.1.2 Degree of protection

The degree of protection IP of the equipment as defined in the IEC publication 529 is to be suitable for their location onboard. Depending on its location onboard, the equipment is to be provided with a protection index IP as given in Tab 1.

##### 1.1.3 Conditions of operation

Unless otherwise specified, all electrical equipment is to be operated satisfactorily in the conditions listed below, whether simultaneously or not:

- permanent list of 15°
- ambient temperature of 45°C (onboard ships intended for service inside tropical waters the standard ambient temperature is to be taken equal to 45°C and the cooling water to 30°C)
- when voltage and frequency variations in transient operation reach:
  - $\pm 0,2 U_n$  (1,5 seconds)

$\pm 0,1 F_n$  (3,0 seconds)

$U_n$  and  $F_n$  being respectively the rated voltage and frequency of the network

- when the voltage and the frequency in steady conditions vary respectively of their rated value:

$\pm 0,06 U_n - 0,10 U_n$

$\pm 0,05 F_n$

##### 1.1.4 Innovative designs

The Society reserves the right, whenever deemed necessary or justified, to alter some requirements of the present Rules or to call new ones to take into consideration particular characteristics of a piece of equipment or of a definite installation. In particular, it may carry out a special examination of equipment, installation or project of installation, when these are based on new principles or arrangements not explicitly governed by the present Rules.

**Table 1 : Protection index IP**

Location	Protection index	Exceptions
Dry accommodation spaces Dry control rooms	IP 20	
Control rooms (navigation bridges) Engine and boiler rooms above the lower floor Steering gear rooms Refrigerating machinery rooms Emergency machinery rooms General store rooms Pantries Provisions rooms	IP 22	
Bathrooms and showers Engine and boiler rooms below the lower floor Closed fuel oil separator rooms Closed lub oil separator rooms Ballast pump rooms Refrigerated rooms Galley and laundries	IP 44	
Shaft tunnels or pipe tunnels in double bottom Holds for general cargo	IP 55	
Weather decks	IP 56	Lighting fittings (IP 55)
<b>Note 1:</b> The case of immersed equipment is specially examined. Where the Table cannot be applied, compensatory dispositions are to be used to the Surveyor's satisfaction.		

## 2 Distribution

### 2.1 Distribution systems

2.1.1 The following distribution systems may be used.

- Direct current:
  - two-wire systems with one possibly earthed
  - three-wire systems with the mid-wire earthed.
- Alternative current:
  - two-wire single phase systems with one possibly earthed
  - three-wire three phase systems with neutral either insulated or earthed, directly or through an impedance
  - four-wire three phase systems with neutral insulated from earth.

- Distribution with hull return:

In hull return systems, every conductor carrying the current from a circuit to the hull is to have the same cross-section as the corresponding insulated conductor. In DC, one pole of generator and of supplied appliances is to be earthed in readily accessible places.

### 2.2 Insulation level monitoring

2.2.1 The networks insulated from earth are to be provided with suitable means to indicate the insulation level.

### 2.3 Earthing of metal parts of electrical installations

2.3.1 When it is required for the equipment supplied under a voltage above 50 volts, the connection to the earth is to be of copper or other corrosion resistant conductive material, securely installed and protected, where necessary, against mechanical damage and electrolytic corrosion.

### 2.4 Earth continuity

2.4.1 Onboard ship with non-metallic hull, bonding is to be provided between the frame of the generators, the bed plate of the pumps, the bed plate of the motors and the earth plate, if fitted. All the elements of the fuel installation are to be electrically bonded and connected to the above bonding.

### 2.5 Emergency power sources and circuits

#### 2.5.1 General

- a) All ships are to be provided with an emergency power source.
- b) The emergency source of power may be:
  - a generator set provided with an independent fuel supply and a cooling system independent from the main engine
  - or a storage battery.

- c) The emergency source of power and associated switch-board are to be located outside the machinery room and above the main deck.

Where the above provisions cannot be fulfilled, the emergency source of power may, with the agreement of the Society, be located under the main deck in a room accessible from the deck and protected with watertight and fire-resisting decks and bulkheads.

- d) The available power of the emergency source of power is to be adequate for a period of no less than 6 hours. Nevertheless, for ship engaged regularly on voyages of short duration, the Society, being satisfied that an adequate standard may be attained, may accept a lesser period.
- e) For ship where the start of the main engine is carried out by electrical starter and where the emergency source of power is a storage battery, the emergency source of power can be considered as the second required starting power source for the main engine.

Then:

- the starting system cables are to be designed to permit the necessary commutation with a change over switch and fixed connections
- the available power of the emergency battery is to be adequate to supply the services mentioned in [2.5.2] during the time specified in item d) and, in principle, have the capacity of six consecutive starts of the main engine.

#### 2.5.2 Services carried out

The emergency power sources are to be at least capable of ensuring that, where mandatory and insofar as the installations do not have independent emergency supplies, the following electrical installations can run simultaneously:

- navigation light
- sound signals
- emergency lighting
- radio telephone
- general alarm or appropriate loudspeaker system, manual fire alarm
- fire detection and fire extinguishing system
- fire pump, emergency pump, when required
- all service equipment required in an emergency.

#### 2.5.3 Location of the emergency lighting

At least the following posts and location are provided with an emergency lighting:

- location where life-saving appliances are laid, handled and launched
- the exits of the accommodations and alley-ways
- the machinery room and its belts
- the wheel house
- the posts of fire appliance
- the zones of assembling of the passengers and crew in case of emergency.

## 2.6 External source of power

**2.6.1** The socket-outlets used for the supply of the ship from the shore network and when the voltage exceeds 50 volts, are to be provided with a built-in earth connection provided to be connected to the earth.

The equipment is to be designed so that the connection to earth is carried out before the other connections.

**2.6.2** The circuit of the shore supply is to be protected against overloads and short-circuits.

**2.6.3** For a three-phase A.C. system, a phase sequence indicator is to be provided onboard.

## 2.7 Particular provisions

### 2.7.1 Lighting circuits

In the main engine room and passenger spaces, the lights are to be fed by at least two different circuits. One of these circuits may be the one supplied by the emergency source.

### 2.7.2 Navigation lights

The navigation lights are to be connected separately to a distribution board which is reserved for this purpose and directly supplied by the switchboard of the generators. It is to be possible from the bridge to connect the navigation light switchboard by means of a changeover switch to a circuit issued from the emergency switchboard.

When it is not possible to visually check the navigation lights from the navigating control position, a control device is to be provided.

### 2.7.3 Steering gear circuits

Electric or electro-hydraulic steering gear including two units which can be operated independently from one another is to be served by two cables fed by the main switchboard. Nevertheless, it may be accepted that one of the cables also supplies other equipment if they are not operated at sea.

Each circuit is to have sufficient capacity for supplying all the motors which may have to operate simultaneously. The circuits are to be separated as much as possible from one another.

The motors driving the steering gear and their circuits are to be protected only against short-circuits.

Where the steering is power-operated, it is to be provided, at easily visible location for the man at the helm, a rudder angle indication and means to indicate that the motors are running, stopped or overloaded.

### 2.7.4 Fire-detection and fire-alarm

Where fire-detection and fire-alarm system is provided, it is to be supplied from the main source and an emergency source.

The fire-detection system is to be provided with a power failure alarm itself supplied by a power source independent from the others.

### 2.7.5 Fuel pumps - Fans

The motors driving fans and fuel pumps are to be provided with remote control located outside the concerned rooms so that they can be stopped in the event of fire in the room where they are located.

### 2.7.6 Main engine starting system

For the ships with two main engines provided with electrical starter, each main engine is to be equipped with its own starter battery. Each battery is to be capable of being connected with a changeover switch and fixed cables to the starting system of the other main engine.

### 2.7.7 Fixed gas fire extinguishing system

Where a fixed gas fire extinguishing system is provided, the audible and visible warnings on release of the extinguishing medium are to be supplied by an emergency power source and readily distinguishable from the other audible and visible alarms.

### 2.7.8 Alarm - Communication

- a) For the crew muster, an alarm system operated from the bridge is to be provided. This system may be part of the general alarm system.
- b) A loud-speaker system or equivalent is to be provided in the accommodation, service spaces and control stations.
- c) Ships of 12 m or more in length are to be equipped with a system enabling the general broadcast of alarm and messages in case of damage or ship escape.
- d) The bridge operating compartment is to be fitted with the internal communication and control means as quoted hereunder.
  - An engine room telegraph with repeater, or equivalent system, is to be provided and duplicated by another independent system, enabling the communication with the engine control position. If the size and arrangement of the ship make useless the equipment mentioned above, only a dual calling system such as telephone, megaphone or bell may be fitted.
  - If the propelling machinery is remote-controlled from the bridge-operating compartment, at least one order telegraph, reversible or with repeater, is to be fitted at the local direct engine control position.
  - Furthermore, unless the size and arrangement of the ship make useless this equipment, the bridge operating compartment is to be connected by means of a reversible voice communication system to the local control of steering gear, propelling machinery and the service accommodation.
  - From the bridge, a reversible phonic system is to be provided to communicate with the staff in the passenger spaces, except if the bridge and these spaces are directly linked.
  - An alarm is to be triggered at the bridge in case of high water level in the machinery spaces located below the deepest subdivision load line.
- e) Bilge alarms is to be fitted in all bilge spaces.
- f) Internal two-ways means of communication with steering flat / engine room is to be fitted.

### 2.7.9 Final sub-circuits

Every final sub-circuit connected to a distribution panel is to be protected, unless otherwise specified, by a fuse or a maximum current circuit-breaker on each insulated pole.

These circuits can be controlled by single pole switches in dry spaces of the accommodation.

A separate final sub-circuit is to be provided for every apparatus assuming an essential service and for each motor rated 1 kW or more.

## 3 Cables

### 3.1 Choice of cables

**3.1.1** Cables are to be normally of a type approved by the Society. The use of other cables or wire in compliance with National Regulations can be considered. Every cable is to be at least of the flame-retardant type.

### 3.2 Current ratings

**3.2.1** The current rating in the conductors according to their class temperature and cross-section area is not to be higher than the values stated in Tab 2.

This table gives the current ratings valid for an ambient temperature of 45°C.

**3.2.2** Where more than six cables which may be expected to operate simultaneously at their fully rated capacity are laid close together in cable bunch in such a way that there is an absence of free air circulation around them, a reduction factor is to be applied to the current ratings specified in [3.2.1].

**3.2.3** The drop in voltage from the main switchboard to any and every point on the installation is not to exceed 6 % of the nominal voltage.

### 3.3 Cable installation

#### 3.3.1 Choice of runs

Cable runs are to be as straight and accessible as possible.

Cable runs are to be fitted away from source of water. Cables exposed to the risk of mechanical damage, if not armoured or enclosed in steel conduits, are to be protected by a casing.

The cable runs are to be so designed that the internal radius of bend does not exceed at any point the permissible value for the cable concerned. In the absence of values specified by the manufacturer, the following values are to be adopted as minima for the internal radius of bend:

- 4 d for rubber-like insulated cables without metallic covering (6 d if  $d > 25$  mm)
- 6 d for rubber-like insulated cables with metallic covering or for silicone asbestos cables.

**Table 2 : Maximum permissible DC strengths for continuous service, in amps**

Cross section in mm <sup>2</sup>	Temperature class 60°C			Temperature class 75°C			Temperature class 80°C			Temperature class 85°C			Temperature class 95°C		
	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores
1	8	7	6	13	11	9	15	13	11	16	14	11	20	17	14
1,5	12	10	8	17	15	12	19	16	13	20	17	14	24	20	17
2,5	17	15	12	24	20	17	26	22	18	28	24	20	32	27	22
4	22	19	16	32	27	22	35	30	25	38	32	27	42	36	29
6	29	25	20	41	35	29	45	38	32	48	41	34	55	47	39
10	40	34	28	57	49	40	63	54	44	67	57	47	75	64	53
16	54	46	38	76	65	53	84	71	59	90	77	63	100	85	70
25	71	60	50	100	85	70	110	94	77	120	102	84	135	115	95
35	87	74	61	125	106	88	140	119	98	145	123	102	165	140	116
50	105	89	74	150	128	105	165	140	116	180	153	126	200	170	140
70	135	115	95	190	162	133	215	183	151	225	191	158	255	217	179
95	165	140	116	230	196	161	260	221	182	275	234	193	310	264	217
120	190	162	133	270	230	190	300	255	210	320	272	224	360	306	252
150	220	187	154	310	264	217	340	289	238	365	310	256	410	349	287
185	250	213	175	350	298	245	390	332	273	415	353	291	470	400	329
240	290	247	203	415	353	291	460	391	322	490	417	343	570	485	399
300	335	285	235	475	404	333	530	451	371	560	476	392	640	545	448
400	390	332	273	570	485	400	610	519	427	670	570	469	760	646	532
500	455	387	320	655	560	460	695	591	490	770	655	540	---	---	---
600	505	430	355	730	620	510	770	655	540	850	725	595	---	---	---

### 3.3.2 Earthing of metallic sheath

Any exposed metallic coverings of cables is to be electrically earthed.

### 3.3.3 Cable fixing

Cables are to be bunched as regularly as possible.

Cables are to be so arranged as to avoid any friction; if needed, fastening parts are to be used.

The distance between fastening parts is to be defined according to the cable nature and the special installation provisions.

The distance between two fastening parts is generally not to exceed 0,50 m.

### 3.3.4 Cable glands through bulkheads and decks

Where cables are to pass through bulkheads or watertight decks, special protection is to prevent damage to the cables by abrasion.

Cable penetration through watertight decks and bulkheads may consist in either individual stuffing glands or boxes containing several cables and filled with flame-retarding compound.

Where cables pass through decks, the low part of cables is to be protected against possible mechanical damage up to a height of at least 0,20 m from the decks.

### 3.3.5 Installation in conduits

Armoured cables are generally more appropriate than unarmoured cables when fitting in conduits. When metallic conduits are used, the following is to be complied with:

- The inner part of the conduit is to be smooth.
- The ends of the conduit are to be so arranged that the cable sheath cannot be damaged.
- The internal radius of bends is not to be less than what is permitted for cables, nor less than twice the external diameter of the conduit.
- Conduits are to be so arranged that water cannot accumulate inside. If necessary, ventilating and draining is to be provided to allow circulation of air.
- The filling factor (ratio of the sum of the cross sectional areas corresponding to the external diameter of the cables to the internal cross section of the conduit) is not to be greater than 0,4.

### 3.3.6 Connections

- Cable ends

The ends of the conductors having a cross section greater than 4 mm<sup>2</sup> are to be provided with connectors or connected to fastening terminals or equivalent

- Joints

Cable runs are normally not to include joints. When a joint is absolutely necessary, it should be made so that the conductors remain properly insulated and protected. The joints are normally to be made in suitable boxes; the in-line splices are prohibited.

- Tappings

Tappings are to be made by means of boxes and connectors properly designed, according to the same rules as for joints and cable ends.

## 4 Switchboards

### 4.1 Location

**4.1.1** The main switchboards are to be placed far away from flammable gas, vapour accumulation, acid gas or other liquid. Their location is to be such that there is no pipe carrying liquids above, beside or near them. When this cannot be avoided, pipes are to be built jointless or provided with double pipes or shields in these spaces.

### 4.2 Installation

**4.2.1** When the voltage exceeds 50 volts, AC or DC, an insulated mat, grating or impregnated wood surface is to be provided in front of switchboards and also at the rear if access to the rear is provided. The insulated mat, grating or surface is to be oil-resistant and non-slippery.

**4.2.2** The main switchboards are to be provided with insulated handrail or handles on their front. If access is available on their rear, an insulated handrail is also required on rear side.

### 4.3 Design - Construction

**4.3.1** Generally, switchboards or enclosures containing switchboards are to be constructed of durable, flame-retardant and non-hygroscopic materials. In addition, mechanical features of the materials are to be suitable for the service conditions.

**4.3.2** Live parts normally submitted to a voltage exceeding 50 volts are not to be installed without protection on the front of switchboards.

**4.3.3** The switchboard frame or enclosures containing switchboards are to be earthed.

**4.3.4** Air clearances between live parts are to be suitable for the rated voltage or protected by means of insulating and fireproof shields.

**4.3.5** Every switchboard part, including the connections, is to be easily accessible.

### 4.4 Testing - Checking

**4.4.1** The following testing is to be normally carried out on the switchboards.

- High voltage test

The main circuit and the auxiliary circuits connected to it are to be tested with the AC voltages as per Tab 3 within the range of 45-62 Hertz.

For the auxiliary circuits not directly connected to the main circuit, testing voltages is as per Tab 4.

This test is carried out between each of the phases of each circuit and all the other phases of this circuit and

of all the other circuits connected together as well as with the earth.

During this test, all interrupting and protective devices are to be closed; measuring instruments and relays may however be disconnected.

- Measurement of the insulation resistance

Immediately after completion of the high voltage test, the insulation resistance between current carrying parts connected together and earth and between current carrying parts of opposite polarity is to be not less than 1 mega ohm measured under 500 volts DC.

**Table 3 : Testing voltages (main circuit dependant)**

Insulation rated voltage (V)	AC test voltage (rms) (V)
$U_i \leq 60$	1000
$60 < U_i \leq 300$	2000
$300 < U_i \leq 660$	2500
$660 < U_i \leq 800$	3000
$800 < U_i \leq 1000$	3500
$1000 < U_i \leq 1500$	3500
<b>Note 1:</b> DC only	

**Table 4 : Testing voltages (other circuits)**

Insulation rated voltage (V)	AC test voltage (rms) (V)
$U_i \leq 12$	250
$12 < U_i \leq 60$	500
$U_i > 60$	$2 U_i + 1000$ with a minimum of 1500

#### 4.5 Particular provisions for distribution boards, fuse panels and junction boxes

**4.5.1** Distribution boards and fuse panels are to comply with the requirements of article [4], as far as they are applicable.

**4.5.2** The casings of distribution boards and fuse panels are to be of sufficient rigidity and protected against corrosion.

**4.5.3** Junction boxes are to be wholly constructed with durable, non-flammable and non-hygroscopic materials; filling compounds are to be non-flammable.

#### 4.6 Measuring instruments

##### 4.6.1 General

The following instruments are to be normally provided:

- for each generator:
  - one ammeter with mark indicating the normal full load value (for installations where the rated voltage

is below 24 V and fitted with a load limit, only a charge control lamp can be provided)

- one voltmeter
- one lamp indicator to indicate the generator voltage (this lamp may be the supplementary lighting of the control panel)
- one battery charging control lamp
- for each battery one ammeter with two-sided deviation
- for busbars one voltmeter
- for three-phase system, it is to be provided, in addition:
  - one ammeter per phase or one ammeter with commutator permitting to measure the current in each phase
  - one frequency meter
  - one synchronising device if alternators are arranged to run in parallel
  - one wattmeter for alternators over 50 kVA.

##### Protection

Measuring instruments connected to the network and indicator lamps are to be protected by a fuse. Where a measuring instrument and an indicator lamp correspond to the same indication, each one is to be provided with a fuse.

#### 4.7 Use of interrupting and protective devices

##### 4.7.1 General

Every interrupting device placed in a circuit having a return or neutral conductor not directly earthed is to disconnect simultaneously all the lines of said circuit.

No independent interrupting device is to be placed in an earthed conductor; this does not preclude however the fitting of disconnecting links for testing or surveying purposes.

All electrical circuits, generators and motors over 0,5 kW, are to be adequately protected against possible over currents, including short-circuit currents. Selection, location and characteristics of the protective devices are to allow, as far as practicable, the following:

- elimination of failure consequences in order to reduce the risks of non-availability of the network, and fire hazards
- the continuity of service so as to maintain, through the discriminative action of the protective devices, the supply of circuits not directly affected by a fault.

The devices provided are to have a breaking capacity at least equal to the maximum estimated short-circuit current at the point of installation.

The use of an interrupting and protective device not having a short-circuit breaking and/or making capacity at least equal to the maximum estimated short-circuit current at the point where it is installed is allowed, provided that it is backed up by a fuse or by a circuit-breaker having at least the necessary short-circuit rating at the point it is installed.

If the protection of cables against overload current is made by fuses, their rating is to be selected according to the maximum permissible current in the cable.

#### 4.7.2 Protection of generators

DC or AC generators are to be protected against overload and short-circuit currents by means of a multiple circuit-breaker able to disconnect simultaneously every unearthed conductor, and possibly the earthed conductor. For generators of a rated power lower than 50 kW and not intended to run in parallel, this protection may consist of fuses; in that case, an overload indicator or a current limiter is to be provided.

Where generators are arranged for parallel operation, each of them is to be protected against reverse power, unless otherwise justified.

#### 4.7.3 Protection of main switchboard circuits

Each circuit coming from the main busbars is to be protected on each unearthed conductor against high over currents by means of a protective device, the rating of which is appropriate to the wire cross section; the breaking capacity of this protective device is to be at least equal to the maximum estimated short-circuit at the point where it is installed.

#### 4.7.4 Protection of distribution board circuits

Each circuit coming from the distribution boards is to be provided with either a multiple circuit-breaker or a multiple interrupting device and fuses on each unearthed conductor.

The interrupting device may however be omitted if the outgoing circuit feeds another distribution switchboard, or an apparatus located nearby, e.g. in the same compartment, and if an interrupting device is provided at the in-coming feeder of the distribution board.

The interrupting devices connected to the lighting sub-circuits may consist of monopole interrupting device in the dry spaces.

#### 4.7.5 Particular protections

Regarding the internal combustion engine starters supplied from batteries, the corresponding outgoing circuit may be connected before the battery fuses and without any protection.

## 5 Rotating electrical machines

### 5.1 General

#### 5.1.1 Approval

Rotating machines are to be normally type-approved by the Society or at least manufactured according to recognized international or national standards.

#### 5.1.2 Location - Installation

Machines and their gears are to be located in spaces suitably ventilated where flammable dusts, vapours or gases cannot accumulate. Where this condition, in the case of motors, cannot be fulfilled, the Society is to be advised accordingly and the special consideration will be given, after examination, to the proposed arrangements.

Machines and their gear are to be so arranged that their components are shielded from mechanical damage and

also from any damage likely to occur due to external agents such as water, oil and their vapour.

#### 5.1.3 Operating conditions

The rotating machines are to operate satisfactorily under marine operating conditions, especially when ship inclination from the normal attitude gets 15° of list, 10° of trim, or  $\pm 22^{\circ}30'$  of roll.

#### 5.1.4 Earthing

Bed plates and framework of machines or generating sets are to be efficiently earthed; no insulating material is to be placed between the prime movers and the alternators and generally between the prime movers and the driven machines, unless there is one efficient earthing of each part.

### 5.2 Generators

#### 5.2.1 Number and capacity of main generating sets

Generally, where electrical energy is the only means to supply the services necessary to the propulsion and safety of the ship, the main electric power source is to consist of two generating sets.

One propulsion engine being unavailable is not to result in more than one generator being unavailable as well.

The main generating set power is to be such that the services necessary to maintain the normal conditions of operation and habitability are ensured.

In case one of the generating set is stopped, the remaining generating set is to be able to electrically supply the services necessary to the propulsion and safety of the ship.

Subject to the Society's consideration, the main electric power source may only consist of one generating set driven or not from the propulsion engine.

In case this generating set is unavailable, the electric services necessary to the propulsion and safety of the ship are to be supplied with a battery that may be the emergency source.

#### 5.3 Permissible maximum temperature rise for electrical rotating machines

**5.3.1** The permissible limits of temperature rise, particularly for windings, sliding contacts of machines under continuous running conditions, are given in Tab 5, for a cooling air temperature not exceeding 50°C.

**5.3.2** The permissible temperature rise limits for motors supplying a service requiring intermittent power may be specially considered by the Society.

### 5.4 Voltage regulation

#### 5.4.1 DC generators

The voltage regulation is to be ensured with, if necessary, the use of an automatic voltage regulator, particularly in the case of generators driven by a propulsion engine.

**Table 5 : Maximum permissible temperature rises for electrical rotating machines (on the basis of a cooling air temperature not exceeding 50°C)**

Item number	Parts	Method of measurement	Class of insulation		
			E	B	F
1	AC windings DC field windings of DC and AC machines other than those mentioned in 2 Induction windings connected to the commutators	T	55	60	75
		R	65	70	90
2	Low resistance field windings and compensating windings Single-layer field windings with exposed bare surfaces	T or R	65	70	90
		T or R	70	80	100
3	Permanently short-circuited insulated windings	T	65	70	90
4	Permanently short-circuited windings, uninsulated	T	-	-	-
5	Iron cores and other parts not in contact with windings	T	-	-	-
6	Iron cores and other parts in contact with windings	T	65	70	90
7	Commutators Slip rings	T	60	70	70
		T	60	70	90

**Note 1:** The temperature rises of these parts are in no case to reach a value such that there is a risk of damage to any insulating or other material on adjacent parts.

**Note 2:** Method of measurement:

- T = thermometer method  
For measurements carried out by thermometer method on class F insulated windings and on slip-rings and commutators, a thermocouple type thermometer with instantaneous reading is to be used.
- R = resistance method  
On class H, the maximum permissible temperature rises are defined by the Society.

For generators of a power higher than 20 kW and less than 50 kW, the regulation is at least such that, in case of sudden removal of half the rated load, the speed remaining constant, the voltage increase remains lower than 8% in the case of shunt wound generators and 4% in the case of compound wound generators.

#### 5.4.2 AC generators

When the generator driven at its rated speed and giving its rated voltage is submitted, from an initial specified load, to a sudden change of symmetrical load within the limits of specified current and power factor, the voltage is not to fall below 85% of the rated voltage.

The voltage is to be restored within  $\pm 3\%$  of the final steady value in less than 1,5 seconds.

For emergency generators the voltage is to be restored to  $\pm 4\%$  of the final steady value in less than 5 seconds.

In the absence of precise information concerning the initial load of the generator and the maximum value of the applied load, the following values are to be adopted: the initial load is between no load and 60% of the rated power with a power factor of 0,4 lagging, then no load after steady state conditions.

From steady conditions and whatever the initial generator load may be, in case of partial or whole unloading, the voltage is not to exceed 120% of the rated voltage in transient conditions.

In case of short-circuit, generators whose rated power is greater than 50 kW are to be at least capable of withstanding a current equal to 3 times their rated current during 2 seconds.

## 5.5 Generators speed control

**5.5.1** Prime movers for driving generators are to be fitted with a speed regulator in such a way that at all loads between no load and rated power the permanent speed variations cannot exceed 5% of the rated speed.

For Diesel generating sets, when the rated power is suddenly thrown off, the transient speed variations are not to exceed 10%.

**5.5.2** The generators driven by the propulsion engine, by a geared shaft or by an auxiliary set intended for another purpose, are to be designed with consideration of the modifications of the number of revolutions which may occur in service.

## 5.6 Construction of electrical rotating machines

**5.6.1** The oil-lubricated bearings are to be so arranged that there is no oil leakage whatever the position and movement of the ship in normal conditions and in the conditions specified in [5.1.3].

## 5.7 Control and regulation devices for electrical rotating machines

### 5.7.1 General

The control and regulation devices for machines, e.g. voltage regulation, speed regulation, starters, are to comply with [5.1] to [5.6], where applicable, regarding the loca-

tion, installation, mechanical protection, accidental contacts and protection against solid bodies and liquids.

### 5.7.2 Construction

The control and regulation devices mentioned in [5.7.1] are to be so designed that they can be operated satisfactorily under different ship-sailing conditions, as well as in shock and vibration conditions that may occur.

### 5.7.3 Particular provisions for the motor control device - Starters

DC and AC motors of more than 0,5 kW are to be fitted with a under-voltage protection and a protection against overload. Under-voltage protection may not be provided for steering gear motor or any other motor the continuous running of which is vital.

When the starter, the selector switch or all other equipment used to cut off completely the feed of the motor is at a distance from it, it is recommended that one of the following measures be applied:

- locking of the disconnecting switch of the circuit in open position, or removable fuses
- installation near to the motor of a second disconnecting switch.

## 5.8 Testing of electrical rotating machines

**5.8.1** Machines of a power higher than 1 kW, not type-approved and assuming a service essential to the propulsion and safety of the ship, are to be submitted to type-tests according to a programme approved by the Society. These tests are to be witnessed by a Surveyor or in compliance with an approved procedure.

## 6 Accessories

### 6.1 General provisions

**6.1.1** Used materials are to be durable, non hygroscopic, flame-retardant and corrosion-resistant.

**6.1.2** The protection index IPXX of the equipment or of their envelopes is to be in accordance with the requirements given in [1.1.2].

**6.1.3** When fitted in places where flammable gases or vapours may accumulate, or in rooms intended to mainly contain accumulators, paint or similar material, the equipment is to be of a safety type approved by the Society.

**6.1.4** Particular attention is to be paid to the fixing of equipment made of cast brass or other copper alloys on aluminium decks or bulkheads.

### 6.2 Connection boxes

**6.2.1** Where boxes are filled with an insulating compound, it is to be of a suitable, flame-retardant type.

## 6.3 Socket-outlets

**6.3.1** Socket-outlets rated over 16 A are to be normally provided with a switch.

**6.3.2** Socket-outlets provided with an earthing plug are to be so designed that this plug operates before the others during the plug-in operation. It must be impossible to introduce the earthing plug in unsuitable hole.

## 6.4 Heaters

**6.4.1** Electric radiators are to be permanently installed. They are to be constructed and installed in such a way that clothing or other combustible objects cannot be left there or be hung above these radiators.

## 6.5 Interrupting and protective devices

### 6.5.1 General

The following requirements apply to interrupting and protective devices used in main switchboards, section boards, distribution boards, starters, etc., excluding installation apparatus such as socket-outlets, cabin switches or equivalent.

### 6.5.2 Approval

The devices are normally to be type-approved by the Society, or in compliance with national or international equivalent standards. Necessary justifications may be required. Furthermore, the Society may require the justification of the interrupting and protective device characteristics by means of testing.

## 6.6 Lighting devices

**6.6.1** Light fittings exposed to risks of mechanical damage are to be suitably protected or strongly built.

## 6.7 Electronic equipment

**6.7.1** In addition to the requirements of the present Section, the requirements of Part C, Chapter 3 are applicable to the electronic equipment used for essential services.

## 6.8 Transformers

**6.8.1** The transformers used for services essential to the propulsion and safety of the ship are normally to be type-approved by the Society, or manufactured according to a recognized international or national standard.

**6.8.2** The power transformers of more than 1 kVA (single-phase) or 5 kVA (three-phase) are to be submitted to type-tests according to a programme approved by the Society and witnessed by a Surveyor or in compliance with an approved procedure.

## 7 Storage batteries

### 7.1 Conditions of installation

**7.1.1** Batteries which can be charged by a power exceeding 2 kW (calculated from the maximum charging current of the charging apparatus and from the nominal voltage of the battery) are to be installed in a ventilated suitable space or in a locker protected from dangerous gas accumulation.

**7.1.2** Except for the batteries used as emergency source, small batteries of less than 2 kW may be placed in the machinery spaces, provided they are protected from falling objects and drops of water, the casing being designed to permit the free escape of gases.

**7.1.3** All spaces especially reserved for batteries, including lockers or chests, boxes, shelves are to be protected against the deleterious effects of the electrolyte. The batteries are to be so manufactured and installed that no electrolyte discharge may occur under 22°5 inclination.

**7.1.4** No electrical equipment, except lighting fittings of a safety type-approved by the Society, is to be installed in battery rooms.

### 7.2 Ventilation

**7.2.1** Battery rooms and lockers are to be ventilated, either by natural ventilation, or by ventilating fans.

Natural ventilation may be employed if ducts can be run directly from the top of the room or locker to the open air above, with no part of the duct at more than 45° from the vertical. These ducts are not to contain appliances which may impede the free passage of air or gas mixtures.

**7.2.2** If natural ventilation is impracticable or insufficient, mechanical exhaust-ventilation is to be provided with exhaust at the top of the room or locker. In such a case:

- adequate openings for air inlets, connected to ducts, are to be provided near the floor of battery rooms or the bottom of lockers or boxes
- the fan motor is to be placed external to the duct; possible friction of blades on fixed parts is not to result in sparking.

**7.2.3** Deck boxes are to be provided with exhaust ducts on top and air inlets at lower part. The assembly is to be suitably weather-proof.

For battery of low capacity, only openings on the top of the battery box are required.

### 7.3 Particular provisions

**7.3.1** The battery terminals are not to be of a type dependent on a spring strain.

**7.3.2** A switch or equivalent device accessible and able to fully disconnect the battery from the ship circuits is to be fitted as close to the battery as possible. The alarm systems for gas accumulation or robbery, the automatic bilge pumps, the navigation lights protected by separated fuses or circuit-

breakers may be connected between the battery and the general switch.

## 8 Lightning conductors

### 8.1 General

**8.1.1** A lightning conductor is to be made of continuous copper tape or rope having a section not less than 75 mm<sup>2</sup> riveted or fastened to a copper spike not less than 12 mm in diameter, projecting at least 150 mm above the top of the mast.

The copper rope is to be securely clamped to a copper plate not less than 0,2 m<sup>2</sup> in area, fixed below the light load waterline, or to a metallic piece equivalent for the purpose.

**8.1.2** Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided. No connection is to be dependent on a soldered joint.

### 8.2 Particular applications

**8.2.1** In ships with composite masts, a lightning conductor is to be fitted as specified in [8.1] with the lower part connected to the hull.

**8.2.2** In ships with steel masts, if an electrical continuity between the hull and masts exists, no additional lightning protection is required.

## 9 Tests

### 9.1 General

**9.1.1** Before a new installation is put into service, the tests specified in this article are to be carried out.

These tests do not substitute for the tests carried out at maker's works on the various items of the system.

### 9.2 Insulation level measurement

#### 9.2.1 Switchboards

Insulation level is to be measured between each insulated busbar and earth and between insulated bars. The test is to be made with all switches and circuit-breakers open, bar switches may remain closed; fuses for pilot lamps, earth indicators, voltmeters, etc., are to be removed and voltage coils disconnected.

Recorded level values are to be at least 1 megaohm.

#### 9.2.2 Lighting and power circuits

Measurement is to be made on each fixed cabling, between each conductor and earth and between conductors; values are not to be less than 1 megaohm.

The installation may be subdivided to any desired extent starting from the distribution boards, and appliances may be disconnected if initial tests have given results lower than the requirement. In the latter case; appliances such as radiators, electric cookers, etc., are to be separately subjected to an insulation measurement between live parts and earth and

the values of the measurement are not to be less than 500 k $\Omega$ /kW for each.

### 9.2.3 Internal communication network

Insulation level of any circuit operating at 55 volts or more is to be at least 1 megaohm between conductor and earth and between conductors. Where circuits operate at less than 55 volts, level is to be at least 0,33 megaohm.

Connected apparatuses may be disconnected from the tested circuit, as necessary.

### 9.2.4 Generators and motors

Insulation resistance is to be measured if possible when hot; the value obtained when hot is not to be less than U/1000 megaohm. When testing, all appliances and circuits normally connected between the generator and the first switch are to remain connected.

## 9.3 Particular checking

### 9.3.1 Generators

Generators are to be tested at full rated load for a time sufficient to check the commutation, governing, lubrication and absence of vibrations or abnormal noises.

Generators intended to operate in parallel are to be tested over a range of loads sufficient to check load sharing and parallel operation.

Automatic voltage and speed controls are to be checked when the load is suddenly thrown on and off.

### 9.3.2 Motors

Motors driving essential services, together with their control gear, are to be tested in service conditions.

### 9.3.3 Protection gears

Switch gears are to be tested at a load as near as possible to the working load to check the absence of overheating due to faulty connection or incorrect rating. Circuit-breakers are to be tested, as far as practicable, at the rated load of the circuit they control; checking is made on the working condition of both the switch gears and their control devices. Working condition of the other protection devices (over current, low voltage, back power, reverse current, load shedding relays) is also checked.

### 9.3.4 Earthing

The following earthing elements are to be inspected:

- distribution neutral (if provided)
- metallic structures (on random basis)
- cable shields and cable conduits (on random basis).

In case of doubt, insulation level check may be required.

### 9.3.5 Lighting - Heating

Fixed appliances and corresponding electrical circuits are to be tested in normal working conditions as far as practicable.

### 9.3.6 Internal communication systems

The alarm transmission systems and the order transmitters to the engines, steering gears and windlasses are to be checked.

### 9.3.7 Emergency sources

The good working condition of emergency sources is to be checked. In case the starting and the connection of the emergency power source is automatic, a so-called «black-out» test is to be carried out.

## SECTION 7

## FIRE PROTECTION

### 1 General

#### 1.1 Definitions

**1.1.1** Definitions given in Rules for the Classification of Steel Ships Pt C, Ch 4, Sec 1, [3] are, as a rule, applicable, in particular the qualification of fire and thermal insulation.

#### 1.2 Dangerous goods

**1.2.1** Dangerous goods may be carried provided the relevant provisions of the Rules for the Classification of Steel Ships, Pt C, Ch 4, Sec 11 are complied with.

### 2 Fire prevention

#### 2.1 Structure

**2.1.1** Machinery spaces and wheelhouses are to be separated from other spaces by structural gastight bulkheads and decks in accordance with Tab 1.

**2.1.2** Openings in boundaries mentioned in [2.1.1] are to be restricted to the minimum necessary and are to be fitted with closing devices of at least equivalent fire resistance.

**2.1.3** Doors leading to machinery spaces are to be self-closing.

**2.1.4** Windows and skylights to machinery spaces are to be as follows:

- where skylights can be opened they are to be capable of being closed from outside the space. Skylights containing glass panels are to be fitted with external shutters of steel or other equivalent material permanently attached and wire-reinforced glass is to be used
- glass or similar materials are not to be fitted in machinery space boundaries. This does not preclude the use of wire-reinforced glass for skylights and glass control rooms within the machinery spaces

**2.1.5** The hull, superstructure, structural bulkheads, decks and deckhouses and all other bulkheads and decks not required to be A or B class are to be non-combustible.

**2.1.6** Insulating materials in accommodation spaces, service spaces, control stations and machinery spaces except in refrigerated compartments are to be non-combustible. The surface of insulation fitted on the internal boundaries of machinery spaces is to be impervious to oil or oil vapours.

Exposed surfaces of bulkheads, walls, linings and ceilings in accommodation and service spaces and control stations are to be low flame spread. Seats in public spaces are to be with frames of non combustible materials, with upholstery

having qualities of resistance to ignition and propagation of flame.

#### 2.2 Ventilation

**2.2.1** It is to be possible to stop ventilation fans and to close main openings to ventilation systems from a position outside the spaces served, except in spaces provided with heating stoves.

**2.2.2** Ventilation ducts for main machinery spaces are not in general to pass through accommodation spaces, service spaces or control stations unless the ducts are constructed of steel and arranged to preserve the integrity of the division.

**2.2.3** Ventilation ducts of accommodation spaces, service spaces or control stations are not, in general, to pass through main machinery spaces unless the ducts are constructed of steel and arranged to preserve the integrity of the division.

**2.2.4** Store-rooms containing substantial quantities of flammable products are to be provided with ventilation arrangements which are separate from other ventilation systems. Ventilation is to be arranged at high and low levels and the inlets and outlets of ventilators are to be positioned in safe areas and fitted with spark arresters.

**2.2.5** Ventilation systems serving machinery spaces are to be independent of systems serving other spaces.

### 3 Fire-fighting systems

#### 3.1

**3.1.1** Fixed fire-fighting systems and portable equipment are to be provided, in accordance with Tab 1.

**3.1.2** The independently driven power fire pump is to be independent from the main engine.

**3.1.3** Sanitary, bilge, ballast, general service or any other pumps may be used as fire pumps if they comply with the requirements of this article and do not affect the ability to cope with pumping of the bilges. Fire pumps are to be so connected that they cannot be used for pumping oil or other flammable liquids.

**3.1.4** Fire pump(s) is (are) to be capable of supplying the hydrants referred to in [3.1.4] at the required pressure of at least 2,3 bar.

Remote starting of one fire pump is to be provided from wheel house.

**3.1.5** A sufficient number of fire hydrants and, if necessary, a fire main, fire hoses, nozzles and couplings are to be provided according to Tab 1.

The number and position of hydrants is to be such that at least two jets of water not emanating from the same hydrant, one of each being from a single length of hose, may reach each part of the ship normally accessible.

**3.1.6** Provisions are to be taken to protect exposed fire lines from frost damage.

**3.1.7** Fixed fire-fighting system in engine room, as requested in Tab 1, is to be:

- a pressured water spraying installation
- a gas (CO<sub>2</sub>) system, or
- a high expansion foam system.

The requirements of Pt C, Ch 4, Sec 13 are to be considered for each type of systems.

**3.1.8** Spaces, other than spaces having little or low fire risk, which are not regularly occupied are to be provided with a smoke detection system.

**Table 1 : Fire fighting installation**

Equipment or structural fire protection		
<b>FIRE PUMPS</b>		
Ships greater than 150 GT	Independently driven power pumps	1
	Power pumps	1
Ships less than 150 GT	Power pumps	1
	Hand pumps	1
<b>FIRE HYDRANTS</b>		
Sufficient number and so located that at least one powerful water jet can reach any normally accessible part of ship		X
<b>FIRE HOSES (length &gt; 15 m)</b>		
With couplings and nozzles		≥ 3
<b>HOSE NOZZLES</b>		
Dual purpose (spray/jet) with 12mm jet and integral shut-off. Jet may be reduced to 10mm and shut-off omitted for hand pump hoses		X
<b>PORTABLE FIRE EXTINGUISHERS</b>		
Accommodation and service spaces		3
Boiler rooms, etc		2
Machinery spaces (one extinguisher per 375 kW of internal combustion engine power)		≥ 2
Cargo pump rooms (capacity 9 l. fluid or equivalent)		≥ 2
<b>NON-PORTABLE FIRE EXTINGUISHERS IN MACHINERY SPACES</b>		
Ships greater than 150 GT (capacity 45 l. fluid or equivalent)		1
<b>FIXED FIRE EXTINGUISHING SYSTEMS</b>		
Category A machinery spaces		X
<b>FIREMAN'S OUTFIT</b>		
Ships greater than 150 GT	Complete outfit	≥ 2
Ships less than 150 GT	Complete outfit	≥ 1
<b>MEANS OF ESCAPE</b>		
Accommodation and service spaces		2
Machinery spaces		≥ 1
Cargo pump rooms		1
<b>STRUCTURAL FIRE PROTECTION IN WHEELHOUSE AND MACHINERY SPACES</b>		
Separation from adjacent spaces of negligible fire risk		A-0
Separation from other adjacent spaces		A-60
Escape routes		B-0