Rules for the Classification of Crew Boat

January 2018

Guidance Note
NR490 DT R02 E

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MARINE & OFFSHORE - GENERAL CONDITIONS

1. INDEPENDENCY OF THE SOCIETY AND APPLICABLE TERMS

1.1. The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.

1.2. 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.

1.3. The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of them above listed being relieved of any of their expressed or implied obligations as a result of the interventions of the Society.

1.4. The Services are carried out by the Society according to the applicable Rules and to the Bureau Veritas' Code of Ethics. The Society only is qualified to apply and interpret its Rules.

1.5. The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.

1.6. Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the rules applicable at the time of the Services' performance and con tract's execution.

1.7. The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

2.1. "**Certificate(s)**" means class certificates, attestations and reports following the Society's intervention. The Certificates are an appraisement given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules or to the documents of reference for the Services provided. They 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.

2.2. "**Certification**" means the activity of certification in application of national and international regulations or standards, in particular by delegation from different governments that can result in the issuance of a certificate.

2.3. "**Classification**" means the classification of a Unit that can result or not in the issuance of a class certificate with reference to the Rules.

2.4. "**Client**" means the Party and/or its representative requesting the Services.

2.5. "**Conditions**" means the terms and conditions set out in the present document.

2.6. "**Industry Practice**" means International Maritime and/or Offshore industry practices.

2.7. "**Intellectual Property**" means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and proto cols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.

2.8. "**Parties**" means the Society and Client together.

2.9. "**Party**" means the Society or the Client.

2.10. "**Register**" means the register published annually by the Society.

2.11. "**Rules**" means the Society's classification rules, guidance notes and other documents. 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 minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

2.12. "**Services**" means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: 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.

2.13. "**Society**" means the classification society '**Bureau Veritas Marine & Offshore SAS**', a company organized and existing under the laws of France, registered in Nanterre under the number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.

2.14. "**Unit**" means any ship or vessel or offshore unit or structure of any type or part of it or system 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.

3. SCOPE AND PERFORMANCE

3.1. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

3.2. Subject to the Services performance and always by reference to the Rules, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enters the Unit's class in the Society's Register;
- survey the Unit periodically in service to note that the requirements for the maintenance of class are met. The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

4.1. The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit after surveys; (iii) present the Unit for surveys; and (iv) inform the Society in due course of any circumstances that may affect the given appraisement of the Unit or cause to modify the scope of the Services.

4.2. Certificates referring to the Society's Rules are only valid if issued by the Society.

4.3. The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

5. ACCESS AND SAFETY

5.1. The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawings, etc. required for the performance of the Services must be made available in due time.

5.2. The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

6.1. The provision of the Services by the Society, whether complete or not, involve, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2. Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interests equal to twelve (12) months LIBOR plus two (2) per cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold certificates and other documents and/or to suspend or revoke the validity of certificates.

6.3. In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to solve the dispute.

7. 7. LIABILITY

7.1. The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:

- Indirect or consequential loss;
- Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

7.2. In any case, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cents (150%) of the price paid by the Client to the Society for the performance of the Services. This limit applies regardless of fault by the Society, including breach of contract, breach of warranty, tort, strict liability, breach of statute.

7.3. All claims shall be presented to the Society in writing within three (3) months of the Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

8.1. The Client agrees to release, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services except for those claims caused solely and completely by the negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

9.1. The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2. In such a case, the class granted to the concerned Unit and the previously issued certificates shall remain valid until the date of effect of the termination notice issued, subject to compliance with clause 4.1 and 6 above.

10. FORCE MAJEURE

10.1. Neither Party shall be responsible for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2. For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts

11. CONFIDENTIALITY

11.1. The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, are treated as confidential except where the information:

- is already known by the receiving Party from another source and is properly and lawfully in the possession of the receiving Party prior to the date that it is disclosed;
- is already in possession of the public or has entered the public domain, otherwise than through a breach of this obligation;
- is acquired independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure.

11.2. The Society and the Client shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3. Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4. The Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

12.1. Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.

12.2. The Intellectual Property developed for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain exclusive property of the Society.

13. ASSIGNMENT

13.1. The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to a third party without the prior written consent of the other Party.

13.2. The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1. Invalidity of one or more provisions does not affect the remaining provisions.

14.2. Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3. In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

15.1. The Conditions shall be construed and governed by the laws of England and Wales.

15.2. The Society and the Client shall make every effort to settle any dispute amicably and in good faith by way of negotiation within thirty (30) days from the date of receipt by either one of the Parties of a written notice of such a dispute.

15.3. Failing that, the dispute shall finally be settled by arbitration under the LCIA rules, which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be London (UK).

16. PROFESSIONNAL ETHICS

16.1. Each Party shall conduct all activities in compliance with all laws, statutes, rules, and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption. Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.

16.2. In addition, the Client shall act consistently with the Society's Code of Ethics of Bureau Veritas. http://www.bureauveritas.com/home/about-us/ethics+and+compliance/

RULE NOTE NR 490

Rules for the Classification of Crew Boat

SECTION 1 GENERAL

SECTION 2 HULL SCANTLINGS

SECTION 3 OUTFITTINGS

January 2018

Section 1 General

1	General	5
	1.1 Application	
	1.2 Navigation Notations	
	1.3 Rules application	
2	Definitions	5
	2.1 Crew boats	
	2.2 Operational conditions	

Section 2 Hull Scantlings

1	Documents to be submitted	6
	1.1 General	
2	General	6
	2.1 Introductory comments	
	2.2 Direct calculations	
	2.3 Units	
	2.4 Definitions and symbols	
	2.5 Protection against corrosion	
	2.6 Rounding-off	
3	Steel and aluminium alloys materials and connections	8
	3.1 General requirements	
	3.2 Steel structures	
	3.3 Aluminium alloy structures	
4	Composite materials	11
	4.1 Application	
	4.2 Principle of design review	
	4.3 Rules safety factors	
5	Construction and testing	13
	5.1 General	
6	Design acceleration	13
	6.1 Vertical acceleration at LCG	
	6.2 Transverse acceleration	
	6.3 Assessment of limit operating conditions	
7	Overall loads	15
	7.1 General	
	7.2 Bending moment and shear force	
8	Local loads	17
	8.1 Introduction	
	8.2 Loads	
	8.3 Impact pressure on the hull bottom	
	8.4 Impact pressure on bottom of wet-deck of catamaran (including tunnel radius)	
	8.5 Sea pressures	
	8.6 Sea pressures on front walls of the hull	
	8.7 Sea pressures on deckhouses	

8.8 Deck loads
8.9 Pressures on tank structures
8.10 Pressures on subdivision bulkheads

9 Direct calculations for primary structure 20

9.1 General
9.2 Loads
9.3 Structural model
9.4 Boundary conditions
9.5 Checking criteria for primary structure

10 Hull structure scantling 22

10.1 General
10.2 Definitions and symbols
10.3 Global strength
10.4 Fatigue
10.5 Buckling strength of steel structural members
10.6 Buckling strength of aluminium alloy structural members
10.7 Buckling strength of composite structural members
10.8 Plating scantling under local loads
10.9 Scantling of ordinary stiffeners under local loads
10.10 Scantling of primary supporting members under local loads
10.11 Pillars
10.12 Tank bulkheads
10.13 Subdivision bulkheads

Section 3 Outfittings

1 Hull appendages 38

1.1 Propeller shaft brackets
1.2 Waterjets

2 Rudders 39

2.1 General
2.2 Definitions and symbols
2.3 Materials
2.4 Arrangement
2.5 Determination of the force acting on the rudder blade and the torque acting on the rudder stock
2.6 Rudder stock
2.7 Rudder plating
2.8 Rudder pintles
2.9 Rudder couplings
2.10 Single plate rudders

3 Equipment 45

3.1 Documents to be submitted
3.2 General
3.3 Anchoring
3.4 Towing
3.5 Berthing
3.6 Equipment

4 Stabilisation means 50

4.1 General
4.2 Classification process

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, with hull made of steel, aluminium or composite materials, 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 Δ is the moulded full load displacement, in tonnes.

Craft for which $V \geq 10\ L^{0,5}$ shall be individually considered by the Society.

1.1.2 Provisions not specially covered in these Rules are to comply with applicable requirements stipulated in NR467 Steel Ships, Part A, NR600 and NR566.

1.1.3 Ship covered by the present Rules Note are assigned the service notation **crew boat**, as defined in NR467 Steel Ships, Pt A, Ch 1, Sec 2.

1.2 Navigation Notations

1.2.1 As a rule, one of the following navigation notations is to be assigned with reference to significant wave heights H_S which are exceeded for an average of not more than 10 per cent of the year as defined in Sec 2, [6.1.3]:

- **sea area 1**
- **sea area 2**
- **sea area 3**
- **sea area 4**.

The shipyard's table of the maximum allowed ship speed relative to the sea states, characterised by their significant wave height, is indicated in a memoranda.

1.3 Rules application

1.3.1 In the present Rules, references to other Rules of the Society are defined in Tab 2.

1.3.2 Summary table

The applicable Rules of the Society to be considered are indicated in Tab 1.

2 Definitions

2.1 Crew boats

2.1.1 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 Operational conditions

2.2.1 Crew boats are to be operated in relation to the navigation notation assigned as defined in [1.2] within operating conditions defined in Sec 2, [6.3].

2.2.2 Operational speed is 90% of maximum speed.

Table 1 : Summary table

Main subject	Reference
Hull	Sec 2
General arrangement design	NR566, Ch 1, Sec 2
Stability	NR566, Ch 1, Sec 3
Hull integrity	NR566, Ch 1, Sec 4
Outfittings	Sec 3
Machinery	NR566, Ch 2
Electrical and automation	NR566, Ch 3
Fire safety	NR566, Ch 4

Table 2 : References to other Rules of the Society

Reference	Title
NR467 Steel Ships	Rules for the Classification of Steel Ships
NR600	Hull Structure and Arrangement for the Classification of Cargo Ships less than 65 m and Non Cargo Ships less than 90 m
NR566	Hull Arrangement, Stability and Systems for ships less than 500 GT
NR546 Composite Ships	Rules for Hull in Composite Materials and Plywood, Material Approval, Design Principles, Construction and Survey
NR561 Aluminium Ships	Rules for Hull in Aluminium Alloys, Design Principles, Construction and Survey
NR216 Materials & Welding	Rules on Materials and Welding for the Classification of Marine Units

SECTION 2 HULL SCANTLINGS

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 for examination and approval.

1.1.2 In addition, the following informations are to be submitted:

- draught and trim of the craft at sea, at rest and at its maximum speed in calm water
- any direct calculations performed.

When deemed necessary, the following informations may be required:

- results of model tests and full-scale measurements
- longitudinal weight distribution and position of the longitudinal centre of gravity of the craft
- design loading conditions including:
  - still water bending moments (SWBM) distribution
  - still water shear force (SF) distribution
  - description of corresponding loading cases.

1.1.3 For hull made of composite materials, additional informations defined in NR546 Composite Ships, Sec 1, [4.2] are to be submitted.

2 General

2.1 Introductory comments

2.1.1 This Section contains the requirements for the determination of the hull scantling.

Attention is drawn to the selection of building materials which is not only to be determined from strength consideration, but should also give consideration to structural fire protection and associated class requirements or Flag Administration requirements where applicable.

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 Article [9].

Such calculations are to be carried out based on structural modelling, loading and checking criteria described in Article [9]. Calculations based on other criteria may be accepted if deemed equivalent to those laid down by the Society.

Table 1 : Structural plans to be submitted

Plan	Containing information relevant to:
Midship section Main sections	• moulded dimensions, maximum service speed V, design acceleration a_{CG} and, if known, limit wave height (see [6.3]) • materials • typical structural details
Longitudinal sections	• structural details • openings in longitudinal girders
Decks	• typical structural details • openings • deck loads, if different from Rule loads
Shell expansion	• plating • materials • typical structural details • position of butt and seam welds • openings
Machinery space structure	• machinery mass and position of centre of gravity • typical structural details • openings
Watertight bulkheads	• openings • typical structural details • openings • pipe passages
Deckhouses	• materials • details of connections between different materials • typical structural details
Rudder	• rudder stock material and scantlings
Propeller shaft brackets	• materials, scantlings, connection details
Equipment	• calculation of equipment number • equipment specification
Testing plan	• position of air vents • testing pressures

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

2.4 Definitions and symbols

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

- Aft end:

  hull region abaft of 0,1 L from the aft perpendicular
- Bottom:

  the bottom is the part of the hull between the keel and the chines
- 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° to the horizontal
- Deadrise angle α_d:

  for hulls that do not have a clearly identified deadrise angle, α_d is the angle between the horizontal and a straight line joining the keel and the chine
- 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
- Fore end:

  hull region forward of 0,9 L from the aft perpendicular
- Hull:

  the hull is the outer boundary of the enclosed spaces of the craft, except for the deckhouses, as defined below
- Main deck:

  the main deck is the uppermost complete deck of the hull. It may be stepped
- Midship area:

  hull region between 0,3 L and 0,7 L from the aft perpendicular.
- 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
- Side:

  the side is the part of the hull between the chine and the main deck

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

C_B : Total block coefficient, defined as follows:

$$C_B = \frac{\Delta}{(1,025 \cdot L \cdot B_W \cdot T)}$$

For catamarans, B_w is to be measured at one float and Δ is to be taken equal to half the total displacement value

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)

Δ : Moulded displacement at draught T, in sea water (mass density = 1,025 t/m^3), in tonnes

FP : Forward perpendicular, i.e. the perpendicular at the intersection of the waterline at draught T and the foreside of the stem

g : Acceleration of gravity, equal to 9,81 m/s^2

L : Rule length, in m, equal to L_{WL} where L_{WL} is the waterline measured with the craft at rest in calm water

LCG : Longitudinal centre of gravity of the craft

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

V : Maximum service speed, in knots.

2.5 Protection against corrosion

2.5.1 Scantlings stipulated in Article [10] 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 (e.g. 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 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 Steel and aluminium alloys materials and connections

3.1 General requirements

3.1.1 This Article defines the main characteristics to take into account for steels and aluminium alloys within the scope of the determination of the hull scantling as defined in the present Rules.

3.1.2 Materials with different characteristics may be considered, provided their specification (manufacture, chemical composition, mechanical properties, welding,...) is submitted to the Society for approval.

3.1.3 Testing and manufacturing process

Materials are to be tested in compliance with the applicable requirements of NR216 Materials and Welding.

The requirements of this Section presume that welding and other cold or hot manufacturing processes (parent material types and welding, preheating, heat treatment after welding,...) are carried out in compliance with current sound working practice and the applicable requirements of NR216 Materials and Welding.

3.2 Steel structures

3.2.1 Steels for hull structures, forgings and castings

The characteristics of steels to be used in the construction of ships are to comply with the applicable requirements of NR216 Materials and Welding.

3.2.2 Mechanical characteristics

The mechanical characteristics of steels are to comply with the requirements of NR467 Steel Ships, Pt B, Ch 4, Sec 1, and in particular the:

- grade of steel to be used for the various strength members of the structure
- steels for forging and casting.

Tab 2 gives for information the mechanical properties of steels currently used in the construction of ships.

Higher strength steels other than those indicated in Tab 2 are considered by the Society on a case-by-case basis.

When steels with a minimum specified yield stress R_{eH} other than 235 N/mm² are used, hull scantlings are to be determined by taking into account the material factor k defined in [3.2.3].

3.2.3 Material factor k for scantlings of structural members

The value of the material factor k to be introduced into formulae to check structures given in this Section is a function of the minimum yield stress R_{eH} value specified for the steel to be used.

Tab 3 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/mm².

The use of steels for which $R_{eH} > 355$ N/mm² 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/mm², 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 3 is allowed, the values of the material factor k may be determined by means of linear interpolation.

3.2.4 Welding

The requirements for the scantling and joint design of welded connection of ships built in steel materials are defined in NR600, Chapter 6, Section 2.

Table 2 : Mechanical characteristics

Steel grades $t \leq 100$ mm	Minimum yield stress R_{eH} , in N/mm²	Ultimate minimum tensile strength R_m , in N/mm²
A-B-D-E	235	400 - 520
AH32-DH32-EH32 FH32	315	440 - 590
AH36-DH36-EH36 FH36	355	490 - 620
AH40-DH40-EH40 FH40	390	510 - 650
Note 1: Refer to NR216 Materials and Welding, Ch 2, Sec 1, [2].		

Table 3 : k factor

R_{eH} (N/mm²)	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 characteristics of aluminium alloys to be used in the construction and their testing process are to comply with the applicable requirements of the following Rules:

- NR216 Materials and Welding
- NR561 Aluminium Ships.

The list of aluminium alloys given in Tab 4 and Tab 5 for information only 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.

Unless otherwise specified, the Young's modulus for aluminium alloys is equal to 70000 N/mm² and the Poisson's ratio equal to 0,33.

The main symbols considered in the present article are:

R_m : Tensile strenght, in N/mm², of the parent metal in delivery condition, as specified (see Tab 4 or Tab 5)

R'_m : Tensile strenght, in N/mm², of the parent metal in as-welded condition

$R_{p0,2}$: Proof stress (yielding strenght), in N/mm², of the parent metal in delivery condition, as specified (see Tab 4 or Tab 5)

$R'_{p0,2}$: Proof stress (yield strenght), in N/mm², of the parent metal in as welded condition.

The mechanical characteristics given in Tab 4 and Tab 5 correspond to general standard values. For more information, refer to the minimum values guaranted by the product supplier.

3.3.2 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 Section 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 $R'_{p0,2}$, in N/mm², 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/mm² (see Tab 4).

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.

Table 4 : Mechanical properties for rolled products with 3 mm ≤ t ≤ 50 mm

Grade	Temper condition	Thickness t (mm)	Yield strength $R_{p0,2}$ min (N/mm²)	Tensile strength R_m min or range (N/mm²)	Elongation min (%) **(1)**	
					$A_{50\,mm}$	A_{5d}
5083	O / H111	3 ≤ t ≤ 50	125	275 - 350	16	14
	H112	3 ≤ t ≤ 50	125	275	12	10
	H116	3 ≤ t ≤ 50	215	305	10	10
	H321	3 ≤ t ≤ 50	215 - 295	305 - 385	12	10
5383	O / H111	3 ≤ t ≤ 50	145	290		17
	H116	3 ≤ t ≤ 50	220	305	10	10
	H321	3 ≤ t ≤ 50	220	305	10	10
5059	O	3 ≤ t ≤ 50	160	330		24
	H111	3 ≤ t ≤ 50	160	330	24	24
	H116	3 ≤ t ≤ 20	270	370	10	10
		20 < t ≤ 50	260	360	10	10
	H321	3 ≤ t ≤ 20	270	370	10	10
		20 < t ≤ 50	260	360	10	10
5086	O / H111	3 ≤ t ≤ 50	95	240 - 305	16	14
	H112	3 ≤ t ≤ 12,5	125	250	8	
		12,5 < t ≤ 50	105	240		9
	H116	3 ≤ t ≤ 50	195	275	10 **(2)**	9
5754	O / H111	3 ≤ t ≤ 50	80	190 - 240	18	17
5456	O	3 ≤ t ≤ 6,3	130 - 205	290 - 365	16	
		6,3 < t ≤ 50	125 - 205	285 - 360	16	14
	H116	3 ≤ t ≤ 30	230	315	10	10
		30 < t ≤ 40	215	305		10
		40 < t ≤ 50	200	285		10
	H321	3 ≤ t ≤ 12,5	230 - 315	315 - 405	12	
		12,5 < t ≤ 40	215 - 305	305 - 385		10
		40 < t ≤ 50	200 - 295	285 - 370		10

(1) Elongation in 50 mm applies for thicknesses up to and including 12,5 mm and in 5d for thicknesses over 12,5 mm.
(2) 8% for thicknesses up to and including 6,3 mm.

Table 5 : Mechanical properties for extruded products with 3 mm ≤ t ≤ 50 mm

Grade	Temper condition	Thickness t (mm)	Yield strength $R_{p\,0,2}$ min (N/mm²)	Tensile strength R_m min or range (N/mm²)	Elongation min (%) **(1) (2)**	
					A_{50mm}	A_{5d}
5083	O	3 ≤ t ≤ 50	110	270 - 350	14	12
	H111	3 ≤ t ≤ 50	165	275	12	10
	H112	3 ≤ t ≤ 50	110	270	12	10
5383	O	3 ≤ t ≤ 50	145	290	17	17
	H111	3 ≤ t ≤ 50	145	290	17	17
	H112	3 ≤ t ≤ 50	190	310		13
5059	H112	3 ≤ t ≤ 50	200	330		10
5086	O	3 ≤ t ≤ 50	95	240 - 315	14	12
	H111	3 ≤ t ≤ 50	145	250	12	10
	H112	3 ≤ t ≤ 50	95	240	12	10
6005A	T5	3 ≤ t ≤ 50	215	260	9	8
	T6	3 ≤ t ≤ 10	215	260	8	6
		10 < t ≤ 50	200	250	8	6
6060 **(3)**	T5	t ≤ 5	120	160	10	10
		5 < t ≤ 25	100	140	10	10
6061	T6	3 ≤ t ≤ 50	240	260	10	8
6106	T5	t ≤ 6	200	250	10	10
6082	T5	3 ≤ t ≤ 50	230	270	8	6
	T6	3 ≤ t ≤ 5	250	290	6	
		5 < t ≤ 50	260	310	10	8

(1) The values are applicable for longitudinal and transverse tensile test specimens as well.
(2) Elongation in 50 mm applies for thicknesses up to and including 12,5 mm and in 5d for thicknesses over 12,5 mm.
(3) 6060 alloy is not to be used for structural members sustaining dynamic loads (slamming and impact loads). The use of 6106 alloy is recommended in that case.

3.3.3 Welding and riveting

The requirements for the scantling and joint design of welded and riveted connections of ships built in aluminium alloys are defined in NR561 Aluminium Ships, Section 3.

3.3.4 Corrosion protection - Heterogeneous steel/aluminium alloy assembly

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.

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).

The conditions for heterogeneous assembly between structures made in aluminium alloys and steel are defined in NR561 Aluminium Ships, Section 3 (see Tab 6).

Table 6 : Aluminium alloys as welded mechanical characteristics

Aluminium alloy	Temper condition	$R'_{p0,2}$	R'_m
5000 series	0	$R_{p0,2}$	R_m
5000 series	other	values of 0 condition	
6005 A (closed sections)	T5 or T6	0,45 $R_{p0,2}$	0,6 R_m
6005 A (closed sections)	T5 or T6	0,50 $R_{p0,2}$	0,6 R_m
6060 (sections) **(1)**	T5	0,43 $R_{p0,2}$	0,5 R_m
6061 (sections)	T6	0,53 $R_{p0,2}$	0,6 R_m
6082 (sections)	T6	0,45 $R_{p0,2}$	0,6 R_m
6106 (sections)	T5	0,33 $R_{p0,2}$	0,54 R_m

(1) 6060 alloy is not to be used for structural members sustaining dynamic loads (slamming and impact loads). The use of 6106 alloy is recommended in that case.

4 Composite materials

4.1 Application

4.1.1 The characteristics of composite materials and their testing and manufacturing process are to comply with the applicable requirements of NR546 Composite Ships, in particular for the:

- raw materials (see NR546, Section 4)
- individual layers and theoretical breaking stresses (see NR546, Section 5)
- laminate characteristics (see NR546, Section 6)
- mechanical tests and raw material homologation (see NR546, Section 11 and Appendix 1).

4.1.2 Attention is drawn to the use of composite materials from a structural fire protection point of view.

The Flag Administration may request that international convention be applied instead of the present requirements, entailing in some cases a use limitation of composite materials.

4.2 Principle of design review

4.2.1 The design review of composite structures is based on safety factors defined as the ratio between the theoretical capacity of the structure and the actual applied stresses, which are to be in compliance with the following criteria:

$$\frac{\sigma_{bri}}{\sigma_{iapp}} \geq SF$$

$$\frac{\sigma_c}{\sigma_A} \geq SF_B$$

where:

σ_A : Compressive stress applied to the whole laminate considered

σ_{bri} : In-plane theoretical individual layer breaking stresses defined in NR546 Composite Ships, Sec 5, [5]

σ_c : Critical buckling stress of the composite element considered defined in NR546 Composite Ships, Sec 6, [4]

σ_{iapp} : In-plane individual layer applied stresses as defined in NR546 Composite Ships, Section 6

SF, SF_B : Rules safety factors defined in [4.3].

In addition, the combined stress criteria in the individual layers defined in NR546 Composite Ships, Sec 2, [1.3.3] is to be greater than the Rules safety factor SF_{CS} defined in [4.3.3].

Note 1: Breaking stresses directly deduced from mechanical tests (as requested in NR546 Composite Ships), may be taken over from theoretical breaking stresses if mechanical test results are noticeably different from expected values.

4.2.2 Type of stresses considered

The following different type of stresses are considered, corresponding to the different loading mode of the fibres:

a) Principal stresses in the individual layers:
- Stress parallel to the fibre (longitudinal direction):

  These stresses, σ_1, may be tensile or compressive stresses, and are mostly located as follows:
  - in 0° direction of unidirectional tape or fabric reinforcement systems
  - in 0° and 90° directions of woven roving.
- Stress perpendicular to the fibre (transverse direction):

  These stresses, σ_2, may be tensile or compressive stresses, and are mostly located as in 90° direction of unidirectional tape or combined fabrics when the set of fibres are stitched together without criss-crossing.
- Shear stress (in the laminate plane) parallel to the fibre. These shear stresses, τ_{12}, may be found in all type of reinforcement systems
- Shear stress (through the laminate thickness) parallel or perpendicular to the fibre. These shear stresses, τ_{13} and τ_{23}, are the same stresses than the interlaminar shear stresses τ_{IL2} and τ_{IL1}
- Combined stress: Hoffman criteria

b) Stresses in the whole laminate:
- Compressive and shear stresses in the whole laminate inducing buckling.

4.2.3 Theoretical breaking criteria

Three theoretical breaking criteria are used in the present Rules:

a) maximum stress criteria leading to the breaking of the component resin/fibre of one elementary layer of the full lay-up laminate

b) hoffman combined stress criteria with the hypothesis of in-plane stresses in each layer

c) critical buckling stress criteria applied to the laminate.

The theoretical breaking criteria defined in a) and b) are to be checked for each individual layer.

The theoretical breaking criteria defined in c) is to be checked for the global laminate.

4.2.4 First ply failure

It is considered that the full lay-up laminate breaking strength is reached as soon as the lowest breaking strength of any elementary layer is reached. This is referred to as "first ply failure".

4.3 Rules safety factors

4.3.1 General

a) The Rules safety factors to be considered for the composite structure check are defined in [4.3.3], according to the type of hull structure calculation check and according to the partial safety factors defined in [4.3.2]

b) Additional consideration on rule safety factors:

   Rules safety factors other than those defined in [4.3.3] may be accepted for one elementary layer when the full lay-up laminate exhibits a sufficient safety margin between the theoretical breaking of this elementary layer and the theoretical breaking of the other elementary layers.

4.3.2 Partial safety factors

As a general rule, the minimum partial safety factors considered are to be as defined as follow:

a) Ageing effect factor C_V:

The factor C_V taking into account the ageing effect of the composites is generally taken equal to:

- for monolithic laminates (or face-skins laminates of sandwich):

  $C_V = 1,2$
- for sandwich core materials:

  $C_V = 1,1$

b) Fabrication process factor C_F:

The factor C_F taking into account the fabrication process and the reproducibility of the fabrication is generally taken equal to:

- in case of a prepreg process:

  $C_F = 1,1$
- in case of infusion and vacuum process:

  $C_F = 1,15$
- in case of a hand lay up process:

  $C_F = 1,25$
- for the core materials of sandwich composite:

  $C_F = 1,0$

c) Type of load factor C_i:

The factor C_i taking into account the type of loads is generally taken equal to:

- for local external sea pressures and internal pressures or concentrated forces:

  $C_i = 1,0$
- for local dynamic sea pressures (slamming loads on bottom and impact on flat bottom on forward area), and for test pressures and flooding loads:

  $C_i = 0,8$
- for longitudinal strength analysis as defined in [10.3] and buckling check as defined in [10.7] where longitudinal stresses are obtained taking into account the total bending moment defined in Article [7]:

  $C_i = 0,8$

d) Type of stress factor C_R:

The factor C_R taking into account the type of stress in the fibres of the reinforcement fabrics and the cores is generally taken equal to:

1) For fibres of the reinforcement fabrics:
   - for tensile or compressive stress parallel to the continuous fibre of the reinforcement fabric:
     - for unidirectional tape, bi-bias, three unidirectional fabric:

       $C_R = 2,1$
     - for woven roving:

       $C_R = 2,4$
   - for tensile or compressive stress perpendicular to the continuous fibre of the reinforcement fabric (unidirectional tape bi-bias, three unidirectional fabric):

     $C_R = 1,0$
   - for shear stress parallel to the fibre in the elementary layer and for interlaminar shear stress in the laminate:
     - for unidirectional tape, bi-bias, three unidirectional fabric:

       $C_R = 1,6$
     - for woven roving:

       $C_R = 1,8$
   - for mat layer:
     - for tensile or compressive stress in the layer:

       $C_R = 2,0$
     - for shear stress in the layer and for interlaminar shear stress:

       $C_R = 2,2$
2) For core materials:
   - for a tensile or compressive stress for cores:

     general case:
     - for a tensile or compressive stress:

       $C_R = 2,1$

     for balsa:
     - for a tensile or compressive stress parallel to the wood grain:

       $C_R = 2,1$
     - for tensile or compressive stress perpendicular to the wood grain:

       $C_R = 1,2$
   - for a shear stress (whatever the type of core material)

     $C_R = 2,5$
3) For wood materials for strip planking:
   - for a tensile or compressive stress parallel to the continuous fibre of the strip planking:

     $C_R = 2,4$
   - for tensile or compressive stress perpendicular to the continuous fibre of the strip planking:

     $C_R = 1,2$
   - for a shear stress parallel to the fibre and for interlaminar shear stress in the strip planking:

     $C_R = 2,2$

4.3.3 Rules safety factors

The Rules safety factors to be considered for the composite structure check are defined according to the type of hull structure calculation.

The Rules safety factors for structure checked under local loads or under global hull girder loads are defined as follows:

- Minimum stress criteria in layers:

  $SF = C_V\ C_F\ C_R\ C_i$

with:

- C_V to be taken as defined in [4.3.2] a) for the check of the structure under local loads
- C_V = 1,1 for the check of the longitudinal strength as defined in [10.3] and for primary structure examined by direct calculation as defined in Article [9].

• Combined stress criteria in layers:

$SF_{CS} = C_{CS}\ C_V\ C_F\ C_i$

with:

- for unidirectional tape, bi-bias, three unidirectional fabric:

  C_{CS} = 1,7
- for other type of layer:

  C_{CS} = 2,1

where:

SF_{CS} : Safety factor calculated according to NR546 Composite Ships, Sec 2, [1.3.3]

• Critical buckling stress criteria:

$SF_B = C_{Buck}\ C_V\ C_F\ C_i$

with:

- for the check of the longitudinal strength as defined in [10.3] and for primary structure examined by direct calculation as defined in Article [9]:

  C_{Buck} =1,35 and C_V =1
- C_{Buck} =1,45 and C_V as defined in [4.3.2] a) when the check of the structure under local loads is carried out.

4.3.4 Rules safety factor for structural adhesive joints

The structural adhesive characteristics are to be as defined in NR546 Composite Ships.

As a general rule, the rules safety factor SF applicable to maximum shear stress in adhesive joint considered in the present Rules is to be calculated as follows:

$SF = 2{,}4\ C_F$

where:

C_F : Factor taking into account the gluing process, and generally taken equal to:

- in case of a vacuum process with rising curing temperature: C_F = 1,4
- in case of vacuum process: C_F = 1,5
- in the other cases: C_F = 1,7.

5 Construction and testing

5.1 General

5.1.1 Hull construction survey and testing procedures within the scope of classification of ships are defined in NR600, Ch 6, Section 3 and:

- NR600, Ch 6, Sec 4 for hull made of steel material
- NR561 Aluminium Ships, Section 9 for hull made of aluminium alloys
- NR546 Composite Ships, Section 11 for hull made of composite materials.

6 Design acceleration

6.1 Vertical acceleration at LCG

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

As a rule, a_{CG} is to be taken not less than:

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

where:

foc : To be taken equal to 0,85

Soc : Value given in Tab 7 in relation to sea area defined in [6.1.3].

Table 7 : Soc values

	Sea area 4	Sea area 3	Sea area 2	Sea area 1
Soc	C_F **(1)**	0,30	0,23	0,14

(1) $C_F = 0,2 + \frac{0,6}{V/\sqrt{L}} \geq 0,32$

6.1.2 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.

6.1.3 Navigation notation

The following navigation notation is assigned based on sea areas defined with reference to significant wave heights H_s which are exceeded for an average of not more than 10 percent of the year:

- **sea area 4** (open-sea service):

  $H_s \geq 4{,}0$ m
- **sea area 3** (restricted open-sea service):

  $2{,}5\ m \leq H_s < 4{,}0$ m
- **sea area 2** (moderate environment service):

  $0{,}5\ m < H_s < 2{,}5$ m
- **sea area 1** (smooth sea service):

  $H_s \leq 0{,}5$ m.

6.1.4 If the design acceleration cannot be defined by the designer, the a_{CG} value corresponding to the appropriate values of foc and Soc defined in [6.1.1] is to be assumed.

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

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

$a_v = k_v \cdot a_{CG}$

where:

a_{CG} : Design acceleration at LCG defined in [6.1.1]

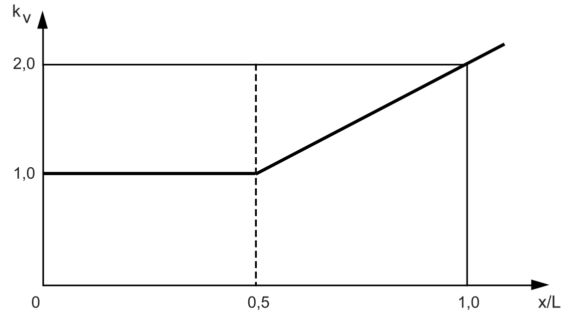
k_v : Longitudinal distribution factor, not to be less than (see Fig 1):

$k_v = 1$ for $x/L \le 0,5$

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

Higher values may be requested based on pitch consideration.

Figure 1 : k_v factor



6.1.7 Variation of a_v in the transverse direction may generally be disregarded.

6.2 Transverse acceleration

6.2.1 Transverse acceleration is defined on the basis of results of model tests and full-scale measurements, considering their characteristic value as specified in [6.3.1].

6.2.2 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 [6.3.2], f))

r : Distance from the point to 0,5 D.

6.3 Assessment of limit operating conditions

6.3.1 General

a) "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

b) limit operating conditions are derived from the restrictions defined in [6.3.2] and [6.3.3] below

c) 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

d) 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 [6.1.3]

e) other specific design parameters influenced by sea state and speed could be also considered at the discretion of the Society

f) 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

g) 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 [6.1]

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.

6.3.2 Limitation imposed by bottom impact pressure and deck loads

a) bottom impact pressure, given in [8.3], and deck loads, given in [8.8], 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:

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

for units for which:

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

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

  and

  $$K_{HS} = 1$$

- $V / L^{0,5} < 3$ 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:

α_{dCG} : Deadrise angle, in degrees, at LCG, to be taken between 10° and 30°

H_s : Significant wave height, in m

τ : Trim angle during navigation, in degrees, to be taken not less than 4°

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 characterized 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 (characterized 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.

6.3.3 Limitation imposed by global loads

The longitudinal bending moment and shear forces as given in [7.2] 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 [6.3.2] items 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.

6.3.4 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.

7 Overall loads

7.1 General

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

In addition, the torsional moment defined in [7.2.6] is to be considered for catamaran.

7.1.2 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 [7.2] must be considered as short term 1/100° values.

7.2 Bending moment and shear force

7.2.1 General

a) The values of the longitudinal bending moment and shear force are given, in first approximation, by the formula in [7.2.2], [7.2.3] and [7.2.4].

b) The total longitudinal bending moments M_{blH}, in hogging conditions, and M_{blS}, in sagging conditions, in kN.m, are to be taken as the greatest of those given by the formulae in [7.2.2] and [7.2.3].

   The total shear forces T_{bl}, in kN, is given by the formula in [7.2.4].

c) The longitudinal distribution of the total bending moment M_{blH} and M_{blS} is given in [7.2.5].

7.2.2 Longitudinal bending moment due to still water loads, wave induced loads and impact loads

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

where:

a_{CG} : Vertical acceleration at the LCG, defined in [6.1].

7.2.3 Longitudinal bending moment due to still water loads and wave induced loads

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

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

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.

7.2.4 Total shear force induced by longitudinal bending moment

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

where:

M_{bl} Greatest between M_{blH} and M_{blS}, calculated according to [7.2.2] and [7.2.3], as applicable.

7.2.5 Longitudinal distribution of total bending moment

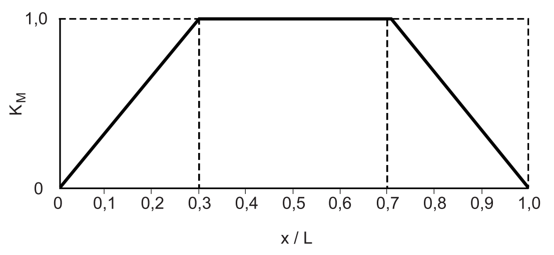
The longitudinal distribution of the total bending moments is given by:

- in hogging: $K_M \cdot M_{blH}$
- in sagging: $K_M \cdot M_{blS}$

where:

K_M : Longitudinal distribution factor as shown on Fig 2.

Figure 2 : K_M factor



7.2.6 Bending moments and shear forces for catamaran

a) Longitudinal bending moments:

The values of the longitudinal bending moment and shear forces, applied to the whole transverse section, are to be calculated as defined from [7.2.1] to [7.2.5].

b) Transverse torsional moment:

In addition, a transverse torsional moment, in kN.m, due to wave induced loads plus impact loads is to be taken into account and is to be not less than:

$M_{tt} = 0,125\ \Delta\ L_{WL}\ a_{cg}\ g$

where:

a_{cg} : Design vertical acceleration as defined in [6.1.1]

a_{cg} need not be taken greater than 1,0 g in this formula

Δ : Total moulded displacement, in t

g : Acceleration of gravity, equal to 9,81 m/s²

L_{WL} : Waterline length of one float, in m.

The bending moments and the shear forces along the floats and in the primary transverse cross structure of the platform induced by the transverse torsional moment are to be determined by a beam model where the transverse cross beams are fixed in the model in way of the inner side shell of one float (see Fig 3).

The other float and the primary transverse cross structure of the plateform are modelled by beams having, as far as practicable:

- vertical and horizontal bending inertia, and
- a shear inertia, and
- a torsional inertia about longitudinal float axis

close to the actual primary structure values.

The forces F, in kN, for the beam model loading are to be successively equal to:

$F = M_{tt} / L_{WL}$

$F = - M_{tt} / L_{WL}$

The global bending moments and shear forces distribution in the float are as shown in Fig 4, and in the primary transverse cross structure as shown in Fig 5.

For the primary transverse cross structure, the bending stresses and shear stresses are to be calculated in way of the modelled float.

Figure 3 : Beam model for catamaran

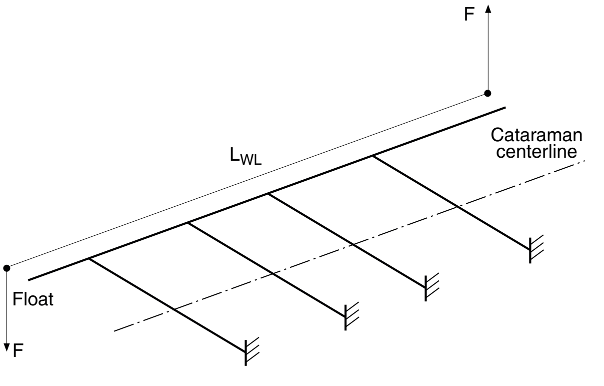


Figure 4 : Longitudinal distribution of bending moments and shear forces

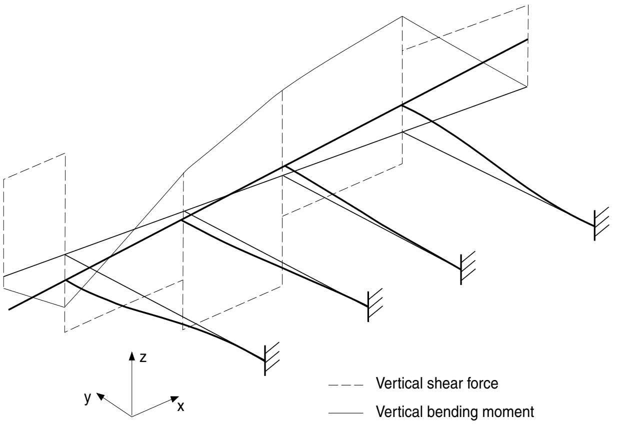
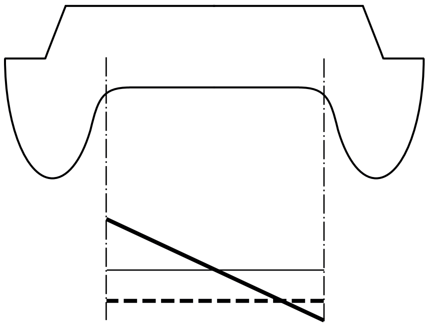


Figure 5 : Transverse distribution of bending moments and shear forces



8 Local loads

8.1 Introduction

8.1.1 Local design loads defined in this Article are to be used for the resistance checks of scantlings of structural elements of hull and deckhouses.

8.1.2 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.

8.1.3 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.

8.2 Loads

8.2.1 General

The following local loads are to be considered:

- 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.

8.2.2 Load points

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

a) Steel and aluminium structure:
   - for panels:
     - lower edge of the plate, for pressure due to hydrostatic and wave load
     - geometrical centre of the panel, for impact pressure
   - for stiffeners:
     - centre of the area supported by the stiffener.

b) Composite structure:
   - for panels:
     - lower edge of the panel for monolithic panel, and at the middle of the panels for sandwich panel, for pressure due to hydrostatic and wave load
     - geometrical centre of the panel, for impact pressure
   - for stiffeners:
     - centre of the area supported by the stiffener.

8.3 Impact pressure on the hull bottom

8.3.1 If slamming is expected to occur, the impact pressure, in kN/m², considered as acting on the hull bottom is to be not less than:

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

where:

Δ : Displacement, in tonnes as defined in [2.4.1]. For catamaran, Δ is to be taken as half of the total displacement

K_1 : Longitudinal bottom impact pressure distribution factor (see Fig 6):
- for $x/L < 0,5$: $K_1 = 0,5 + x/L$
- for $0,5 \le x/L \le 0,8$: $K_1 = 1,0$
- 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

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:
- For steel and aluminium structure:
  - for plating: $K_2 \ge 0,50$
  - for stiffeners: $K_2 \ge 0,45$
  - for girders and floors: $K_2 \ge 0,35$
- For composite structure:
  - for plating and secondary stiffeners: $K_2 \ge 0,15$
  - for girders and floors: $K_2 \ge 0,35$

S_r : Reference area, in m², equal to:

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

Note 1: For catamaran, Δ is to be taken as half of the total displacement for the calculation of S

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

s : Area, in m^2, 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 α_{dCG} is the deadrise angle, in degrees, measured at LCG and α_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 α_d and α_{dCG} are to be between 10° and 30°

a_{CG} : Design vertical acceleration at LCG, defined in [6.1].

8.4 Impact pressure on bottom of wet-deck of catamaran (including tunnel radius)

8.4.1 Slamming on bottom of the wet deck is assumed to occur if the air gap H_A, in m, at the considered longitudinal position is less than z_{wd}, where:

- for L ≤ 65 m: $z_{wd} = 0{,}05 \cdot L$
- for L > 65 m: $z_{wd} = 3{,}25 + 0{,}0214 \cdot (L - 65)$.

In such a case, the impact pressure, in kN/m², considered as acting on the wet deck is not less than:

$$p_{sl} = 3 K_2 K_{WD} V_X V_{SL}\left(1 - 0,85\frac{H_A}{H_S}\right)$$

where:

H_A : Air gap, in m, equal to the distance between the waterline at draught T and the wet deck

H_S : Significant wave height, in m, defined in [6.1.3]

K_2 : Factor accounting for impact area, as defined in [8.3.1]

K_{WD} : Longitudinal wet deck impact pressure distribution factor (see Fig 7):

- for x/L < 0,2:

$$K_{WD} = 0,5\left(1 - \frac{x}{L}\right)$$

- for 0,2 ≤ x/L ≤ 0,7:

$K_{WD} = 0{,}4$

- for 0,7 < x/L < 0,8:

$$K_{WD} = 6\frac{x}{L} - 3,8$$

- for x/L ≥ 0,8:

$K_{WD} = 1{,}0$

V_{sl} : Relative impact velocity, in m/s, equal to:

$$V_{sl} = \frac{4 H_S}{\sqrt{L}} + 1$$

V_X : Ship's speed, in knots

x : Distance, in m, from the aft perpendicular to the load point.

If the wet deck at a transverse section considered is not parallel to the waterline, the impact pressure p_{sl} is to be considered at the discretion of the Society.

Figure 6 : Impact area factor

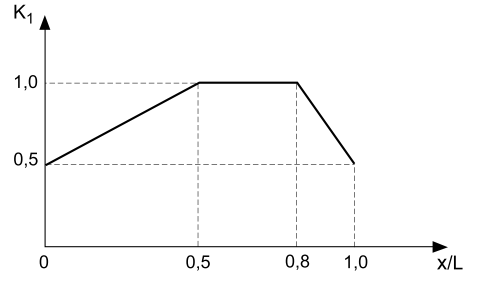
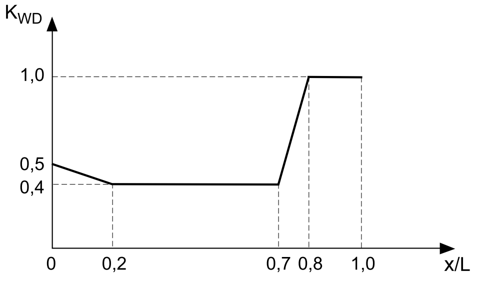


Figure 7 : Distribution factor K_{WD}



8.5 Sea pressures

8.5.1 Sea pressure on bottom and side shell

The sea pressure, in kN/m², considered as acting on the bottom and side shell is to be not less than p_{smin}, defined in Tab 8, nor less than:

- for z ≤ 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:

S : As given, in m, in Tab 8 with C_B taken not greater than 0,5

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

8.6 Sea pressures on front walls of the hull

8.6.1 The pressure, in kN/m², considered as acting on front walls of the hull (in case of stepped main deck), not located at the fore end, is to be not less than:

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

Table 8 : Values of S and p_{smin}

	S	p_{smin}
x/L ≥ 0,9	$T \le 0,36 \cdot a_{CG} \cdot \frac{\sqrt{L}}{C_B} \le 3,5 \cdot T$	$20 \le \frac{L+75}{5} \le 35$
x/L ≤ 0,5	$T \le 0,60 \cdot a_{CG} \cdot \sqrt{L} \le 2,5 \cdot T$	$10 \le \frac{L+75}{10} \le 20$
Note 1: 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.		

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 α), where α is the angle in degree between front wall and deck.

p_{sf} is to be taken not less than the greater of:

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

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

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

8.7 Sea pressures on deckhouses

8.7.1 The pressure, in kN/m², considered as acting on walls of deckhouses is to be 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:
  $K_{su} = 1,5 + 3,5\ b/B$ (with $3 \le K < 5$)
- 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.

8.7.2 The minimum values of p_{su}, in kN/m², 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:
  $p_{su} = 3,0$

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

8.8 Deck loads

8.8.1 General

The pressure, in kN/m², considered as acting on decks is to be not less than:

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

where:

a_v : Design vertical acceleration, defined in [6.1]

p : Uniform pressure due to the load carried, in kN/m², defined in [8.8.2] to [8.8.6].

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

8.8.2 Weather decks and exposed areas

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

- if $z_d \le 2$:
  p = 6,0 kN/m²
- if $2 < z_d < 3$:
  $p = (12 - 3\ z_d)$ kN/m²
- if $z_d \ge 3$:
  p = 3,0 kN/m²

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 areas in way of launching appliances.

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

- if $z_d \le 2$:
  $p = (p_c + 2)$ kN/m², with $p_c \ge 4,0$ kN/m²
- if $2 < z_d < 3$:
  $p = (p_c + 4 - z_d)$ kN/m², with $p_c \ge (8,0 - 2\ z_d)$ kN/m²
- if $z_d \ge 3$:
  $p = (p_c + 1)$ kN/m², with $p_c \ge 2,0$ kN/m²

where:

p_c : Uniform pressure due to deck cargo load, in kN/m², to be defined by the designer with the limitations indicated above.

z_d Distance defined in [8.8.2] a).

8.8.3 Sheltered decks

For shelter decks:

$p = 1,3$ kN/m²

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.

Note 1: Sheltered decks 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. Deckhouses protected by such decks may not have direct access to 'tween-deck below.

8.8.4 Enclosed accommodation decks

a) For enclosed accommodation decks not carrying goods:

   $p = 3,0$ kN/m²

   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 not less than 3,0 kN/m².

8.8.5 Enclosed cargo decks

For enclosed cargo decks: $p = p_c$

where p_c is to be defined by the designer, but taken not less than 3,0 kN/m².

8.8.6 Platforms of machinery spaces

For platforms of machinery spaces: $p = 15,0$ kN/m²

8.9 Pressures on tank structures

8.9.1 The pressure, in kN/m², considered as acting on tank structures is to be 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

ρ : Liquid density, in t/m³ (1,0 t/m³ for water)

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

8.10 Pressures on subdivision bulkheads

8.10.1 The pressure, in kN/m², 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.

9 Direct calculations for primary structure

9.1 General

9.1.1 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.

9.1.2 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 Article [10] are no longer deemed to be effective.

9.1.3 This may be the case, for example, in the following cases:

- 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
- significant racking effects on the structure
- structures contributing to longitudinal strength with large windows in side walls.

9.2 Loads

9.2.1 In general, the loading conditions specified in [9.2.6] to [9.2.10] are to be considered.

9.2.2 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.

9.2.3 The vertical and transverse accelerations are to be calculated as defined in Article [6].

9.2.4 The impact pressure is to be calculated as defined in [8]. 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.

9.2.5 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.

9.2.6 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.

9.2.7 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.

9.2.8 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 [9.2.5]
  - 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.

9.2.9 Combined loading condition 3

The following loads are to be considered when significant racking effects are anticipated:

- 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.

9.2.10 Loading case for catamaran

In addition to the loading cases defined from [9.2.6] to [9.2.9], the loading case defined in [7.2.6] is to be considered.

9.3 Structural model

9.3.1 Primary structures may usually be modelled with beam elements. When the geometry of the structures gives reason to suspect the presence of high stress concentrations, finite element analyses are necessary.

9.3.2 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.

9.3.3 When the stiffness of longitudinal primary members (girders and stringers) is, at least outside the machinery space area, negligible compared with the stiffness of transverse structures (beams, floors and webs), their presence may be taken account of by suitable boundary conditions. It is therefore acceptable in this case to examine primary members in this area of the hull by means of plane analyses of transverse rings.

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

9.3.4 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, 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.

9.4 Boundary conditions

9.4.1 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.

c) Loading case for catamaran:

   General boundary conditions defined in [7.2.6] are to be considered.

9.5 Checking criteria for primary structure

9.5.1 Steel and aluminium structures

a) General:

   For steel and aluminium structure, actual stresses deduced from direct calculations for primary structure are to be not greater than the following allowable values, in N/mm²:
   - 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:

   f'_m : Coefficient depending on the material:
   - for steel structures: 1,00
   - for aluminium alloy structures: 2,15

f_s : Safety coefficient, to be assumed:

- for combined loading conditions: 1,00
- for loading condition in still water: 1,25

K : Material factor defined in Article [3].

b) Buckling:

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 [10.5] and [10.6].

Note 1: In structural elements also subject to high longitudinal hull girder stresses, previous allowable and critical stresses for primary structure check are to be reduced, according to criteria specified by the Society.

9.5.2 Composite structures

For composite structure, the safety factors specified in [4.2.1] deduced from direct calculation for primary structure are to be greater than the rule safety factors defined in [4.3.3].

10 Hull structure scantling

10.1 General

10.1.1 The present Article defines requirements for the scantlings of hull structures (plating, stiffeners, primary supporting members).

As a rule, for ships with a length greater than 24 m, the longitudinal strength check as defined from [10.3] to [10.7] and the structure check under local loads defined from [10.8] to [10.10] are to be carried out. For ships with a length less than 24 m, the structure check under local loads is to be carried out only, the longitudinal strength is considered satisfied when local scantlings are in accordance with requirements defined from [10.8] to [10.10].

10.1.2 As a rule, for speed V greater than 45 knots, the scantlings of transverse structures are to be examined also by direct calculations carried out in accordance with Article [9].

10.1.3 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 Article [9].

10.2 Definitions and symbols

10.2.1 Definition and symbols

b : Actual surface width of the load bearing on primary supporting members

e : Ratio between permissible and actual hull girder longitudinal bending stresses (see [10.3])

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

K : Material factor defined in Article [3]

ℓ : Overall span of stiffeners, in m, i.e. the distance between the supporting elements at the ends of the stiffeners (see Fig 8)

p : Design pressure, in kN/m², defined in Article [8]

s : Spacing of stiffeners, in m, measured along the plating

S : Conventional scantling span of primary supporting members, in m, to be taken as given in Fig 9. Special consideration is to be given to conditions different from those shown

In no case S is to be taken less than (1,1 S_0), S_0 being the distance between the internal ends of the conventional brackets as indicated in Fig 9 or, if there are no brackets, between the ends of the members

σ_{am} : Permissible normal stress, in N/mm²

σ_{bl} : Longitudinal bending stress, in N/mm², as defined in [10.3]

σ_p : Maximum permissible stress, in N/mm², as defined in [10.3.4]

t : Thickness, in mm, of plating

τ_{am} : Permissible shear stress, in N/mm²

μ : Defined as follows:

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

which needs not be taken greater than 1,0

Z : Section modulus, in cm³, of stiffeners and primary supporting members.

10.2.2 Bracket rule

A bracket rule is a bracket with arms equal to ℓ/8, ℓ 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 ℓ is to be that of the member with the greater span, or according to criteria specified by the Society.

10.3 Global strength

10.3.1 Global longitudinal strength

a) General:

As a rule, the longitudinal strength is to be examined for ships having a length greater than 24 m, according to the requirements defined from [10.3] to [10.7] taking into account overall loads defined in Article [7].

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

b) Global longitudinal stress calculation:

Longitudinal stress, in N/mm², in each point of the structures contributing to the craft longitudinal strength is obtained from the following formulae:

- 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:

D : Depth, in m, measured at main deck

M_{bl} : Total bending moment, in kN.m, defined in Article [7]

W_b, W_d : Section modulus, in m^3, 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

For composite structure, the calculation of the longitudinal strength is to be carried out as defined in NR546 Composite Ships, Sec 2 [4]

z : Z co-ordinate, in m, of the calculation point.

c) Scantling criteria:

The values of stress σ_{bl} are not to exceed σ_p, with:

- for steel structures:

  σ_p = 150/K (N/mm²)

- for aluminium alloy structures:

  σ_p = 70/K (N/mm²)

- composite structures:

  for composite structure, the safety factors specified in [4.2.1] deduced from the longitudinal strength calculation are to be greater than the rule safety factors defined in [4.3.3].

Moreover, the compressive values of σ_{bl} are not to exceed the values of critical stresses for plates and stiffeners calculated according to [10.5] for steel structure, [10.6] for aluminium alloy structure and [10.7] for composite structure.

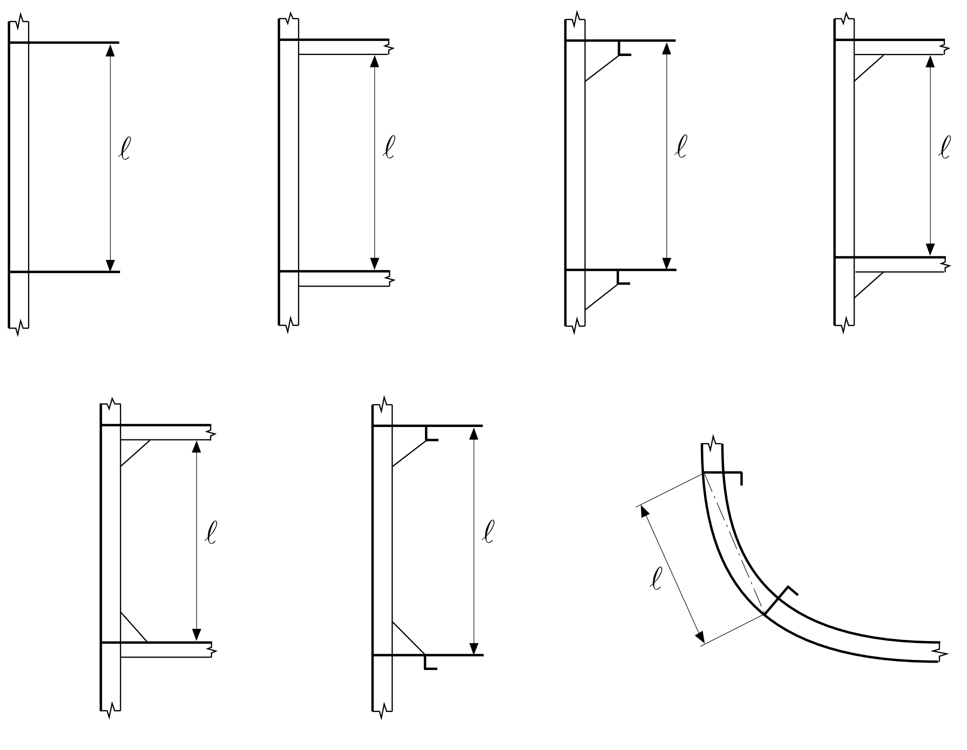
10.3.2 Global strength for catamaran

The overall bending stresses and shear stresses in the float and in the platform of the multihull induced by the global transverse torsional moment are to be directly deduced from the beam model calculation defined in [7.2.6], c) and are to be in compliance with the criteria defined in [10.3.1], c).

Particular attention is to be paid to:

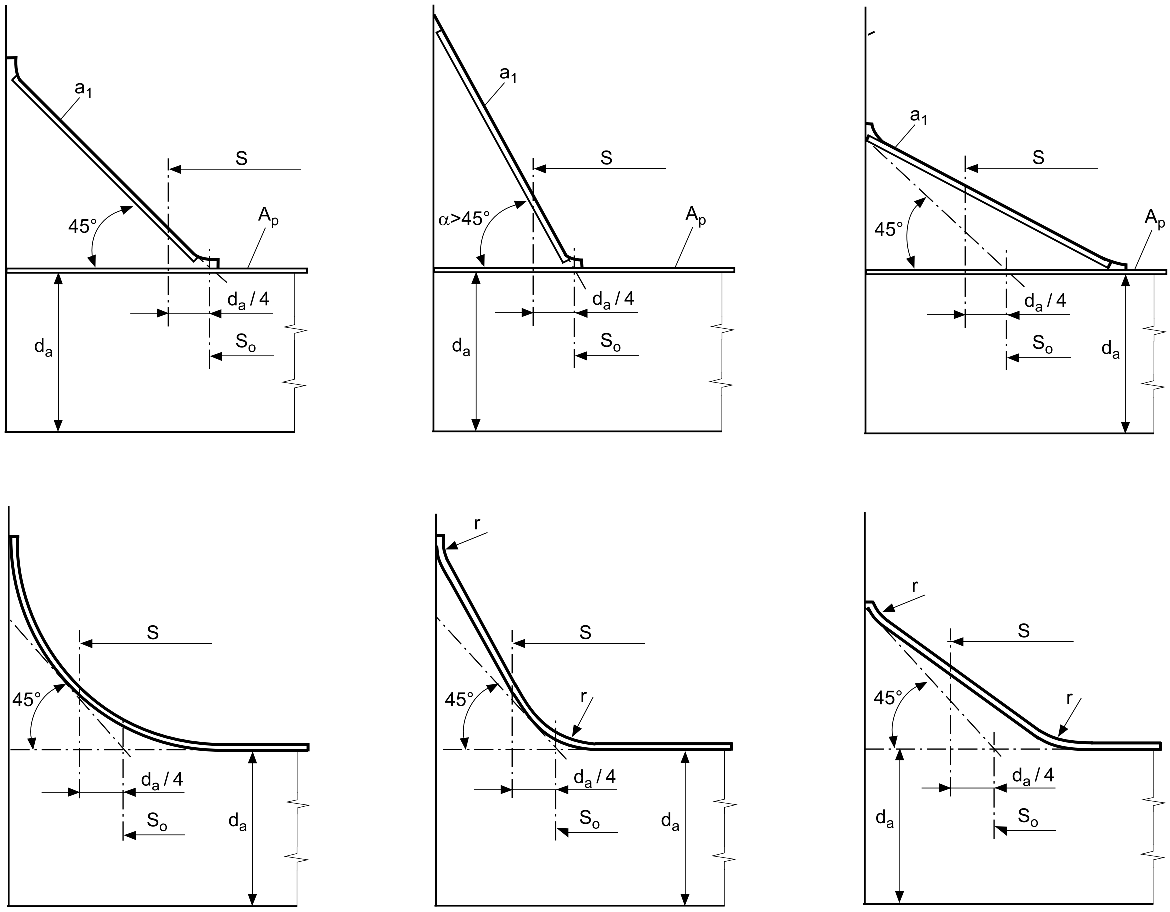
- shear buckling check of cross bulkheads
- compression/bending buckling check of platform bottom and platform deck platings in areas where the bending moment is maximum.

Figure 8 : 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 9 : Examples of conventional scantling spans of primary supporting members



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

10.4 Fatigue

10.4.1 General

The fatigue strength of structural details is to be checked, when deemed necessary by the Society on a case by case basis.

10.4.2 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.

10.5 Buckling strength of steel structural members

10.5.1 Application

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

10.5.2 Elastic buckling stresses of plates

a) Compressive stress:

The elastic buckling stress, in N/mm², is given by:

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

where:

- a : Shorter side of plate, in m
- b : Longer side of plate, in m
- c :
  - When plating is stiffened by floors or deep girders:
    c = 1,30
  - When plating is stiffened by ordinary stiffeners with angle- or T-sections:
    c = 1,21
  - When plating is stiffened by ordinary stiffeners with bulb sections:
    c = 1,10
  - When plating is stiffened by flat bar ordinary stiffeners:
    c = 1,05
- E : Young's modulus, in N/mm², to be taken equal to $2,06 \cdot 10^5$ N/mm² for steel structure
- 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:

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

Ψ : Ratio between smallest and largest compressive stresses when the stress presents a linear variation across the panel ($0 \le \Psi \le 1$)

t : Thickness of plating, in mm.

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 item a) above.

10.5.3 Elastic buckling stress of axially loaded 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/mm², is given by:

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

b) Torsional buckling mode:

For the torsional mode, the elastic buckling stress, in N/mm², is given by:

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

c) Web buckling:

The elastic buckling stress, in N/mm², is given by:

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

where:

A : Cross-sectional area, in cm², of the stiffener, including plate flange

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

E : Young's modulus, in N/mm², to be taken equal to $2,06 \cdot 10^5$ N/mm²

h_w : Web height, in mm

I_a : Moment of inertia, in cm⁴, of the stiffener, including plate flange

I_p : Polar moment of inertia of profile, in cm⁴, 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_t : Saint Venant moment of inertia of profile, in cm⁴, 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_w : Sectional moment of inertia of profile, in cm⁶, 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:

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

ℓ : Span, in m, of the stiffener

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

t_w : Web thickness, in mm

Table 9 : Values of m

C_K	m
$0 < C_k < 4$	1
$4 < C_k < 36$	2
$36 < C_k < 144$	3
$(m - 1)^2 m^2 < C_k \le m^2 (m + 1)^2$	m

b_f : Flange width, in mm

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

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

$\eta_p = \sigma_a / \sigma_{Ep}$

$k_p = 1 - \eta_p$, not to be less than zero

s : Spacing of stiffeners, in m

σ_a : Calculated compressive stress in the stiffener

σ_{Ep} : Elastic buckling stress of plate as calculated in [10.5.2] a)

t : Plate thickness, in mm

t_f : Flange thickness, in mm (for bulb profiles, the mean thickness of the bulb may be used).

10.5.4 Critical buckling stresses and safety factors

a) Compressive stress:

The critical buckling stress in compression σ_c, in N/mm², for plates and stiffeners, is given by:

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

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

where:

R_{eH} : Minimum yield stress of steel used, in N/mm^2

σ_E : Elastic buckling stress calculated according to [10.5.2] a) and [10.5.3]

SF_1 : Safety factor defined in [10.5.4], c).

b) Shear stress:

The critical buckling shear stress τ_c, in N/mm^2, for panels and stiffeners, is given by:

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

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

where:

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

R_{eH} : Minimum yield stress of steel used, in N/mm^2

SF_1 : Safety factor defined in [10.5.4] c).

τ_E : Elastic buckling stress calculated according to [10.5.2] b)

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.

10.6 Buckling strength of aluminium alloy structural members

10.6.1 Application

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

10.6.2 Elastic buckling stresses of plates

a) Compressive stress:

The elastic buckling stress, in N/mm^2, 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 ($0 \le \Psi \le 1$):
  - if $\gamma < \gamma_1$:

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

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

a : Shorter side of plate, in m

c : Unloaded side of plate, in m

d : Loaded side of plate, in m

γ : c/d, not to be greater than 1

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

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

E : Young's modulus, in N/mm^2, to be taken equal to $0,7 \cdot 10^5$ N/mm^2

ε : Coefficient equal to:
- for edge d stiffened by a flat bar or bulb section:
  - if $\gamma \ge 1$: ε = 1,0
  - if $\gamma < 1$: ε = 1,1.
- for edge d stiffened by angle- or T-section:
  - if $\gamma \ge 1$: ε = 1,1
  - if $\gamma < 1$: ε = 1,25.

Ψ : Ratio between smallest and largest compressive stresses when the stress presents a linear variation across the panel ($0 \le \Psi \le 1$)

t : Plate thickness, in mm.

b) Shear stress:

The critical buckling stress, in N/mm^2, 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 item a),

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

b : Longer side of plate, in m.

10.6.3 Elastic buckling stress of axially loaded stiffeners

a) Elastic flexural buckling stress:

The elastic flexural buckling stress σ_E, in N/mm^2, is given by:

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

where:

I : Moment of inertia of the stiffener, in cm^4, calculated with a plate flange of width equal to φ

φ : Smaller of: 800 a, and 200 c

r : Gyration radius, in mm, equal to:

$$r = 10 \sqrt{\frac{I}{S + \varphi \cdot t \cdot 10^{-2}}}$$

S : Area of the cross section of the stiffener, in cm^2, excluding attached plating,

m : Coefficient depending on boundary conditions:
- for a stiffener simply supported at both ends: m = 1
- for a stiffener simply supported at one end and fixed at the other one: m = 2
- for a stiffener fixed at both ends: m = 4 .

b) Local elastic buckling stresses:

The local elastic buckling stresses σ_E, in N/mm², are given by:

- for flat bars:

$$\sigma_E = 5,5 \cdot \left(\frac{t_w}{h_w}\right)^2 \cdot 10^3$$

- 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:

b_f : Flange width, in mm

h_w : Web height, in mm

t_f : Flange thickness, in mm

t_w : Web thickness, in mm.

10.6.4 Critical buckling stresses and safety coefficient

a) Compressive stress:

The critical buckling stress σ_c, in N/mm², is given by:

$$\sigma_c = \frac{\sigma_E}{SF_1} \quad \text{if } \sigma_E \le \frac{R'_{p0,2}}{2}$$

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

where:

$R'_{p\,0,2}$: Minimum guaranteed yield stress of aluminium alloy used, in N/mm², in welded conditions

σ_E : Elastic buckling stress calculated according to [10.6.2], a)

SF_1 : Safety factor defined in item c).

b) Shear stress:

The critical buckling stress τ_c, in N/mm², is given by:

$$\tau_c = \frac{\tau_E}{SF_1} \quad \text{if } \tau_E \le \frac{R'_{p0,2}}{2\sqrt{3}}$$

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

where:

$R'_{p\,0,2}$: As defined in item a)

SF_1 : Safety factor defined in item c)

τ_E : Elastic buckling stress calculated according to item b)

c) Safety factors

The values of safety factors SF_1 are defined in [10.5.4], c).

10.7 Buckling strength of composite structural members

10.7.1 The buckling analysis of composite structure is to be carried out according to NR546 Composite Ships, Sec 6, [4] for panel and NR546 Composite Ships, Sec 7, [5] for stiffeners.

It is to checked that the actual longitudinal stresses calculated according to [10.3] are in compliance with the buckling criteria defined in [4.2].

10.8 Plating scantling under local loads

10.8.1 General

The thickness of plating for steel and aluminium structure are to be calculated according to [10.8.2] to [10.8.9].

Composite plate are to be considered as defined in [10.8.10].

10.8.2 Plating submitted to lateral pressure

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

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

where:

P : Pressures, in KN/m², defined in Article [8]

σ_{am} : Permissible stress, in N/mm², to be taken equal to:
- for bottom plating submitted to impact pressure if occurring:
  - steel structures:

    $\sigma_{am} = 235/K$ (N/mm²)
  - aluminium alloy structures:

    $\sigma_{am} = 95/K$ (N/mm²).
- for other cases:
  - steel structures:

    $\sigma_{am} = 185/K$ (N/mm²)
  - aluminium alloy structures:

    $\sigma_{am} = 85/K$ (N/mm²).

10.8.3 Minimum thicknesses

As a rule, in addition with [10.8.2], the thicknesses of plating are to be not less than the minimum values given in Tab 10.

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	$1,35 \cdot L^{1/3} \ge 2,5$
• Side shell plating and wet deck plating	$1,15 \cdot L^{1/3} \ge 2,5$
Deck plating	2,5
Bulkhead plating	2,5
Deckhouse side shell plating	2,5

10.8.4 Keel

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

10.8.5 Bottom and bilge platings

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

b) 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

c) 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.

10.8.6 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 [10.12]), taking a design pressure p_t, in kN/m^2, equal to:

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

   where

   p_s and p_{sl} are as defined in [8.5] and [8.3] respectively.

10.8.7 Plating of side shell and front walls

a) If front walls are located at the fore end of the hull, the pressure p_{sf} (see [8.6]) 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.

10.8.8 Deck plating

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 [10.12].

10.8.9 Plating of deckhouse walls

a) Openings (doors, windows) are to be well rounded at the corners

b) 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

c) For unprotected front walls located at the fore end, the pressure p_{su} defined in [8.7] and allowable stresses are to be considered individually by the Society.

10.8.10 Scantling of composite panel

The scantling of composite panels is to be checked according to:

- the local loads defined in Article [8]
- the safety factor criteria defined in [4.3]
- the calculation methodology defined in NR546 Composite ships, Section 6.

10.9 Scantling of ordinary stiffeners under local loads

10.9.1 General

The scantling of ordinary stiffeners for steel and aluminium alloy structure are to be calculated according requirements defined from [10.9.2] to [10.9.3].

For composite structures, the scantling of ordinary stiffeners is to be checked according to [10.9.9].

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.

Table 11 : Coefficient m

Type of stiffener	m
Continuous longitudinal stiffeners without Rule brackets at the ends of span	12
Longitudinal and transverse stiffeners with 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

10.9.2 Stiffeners submitted to lateral pressure

The Section modulus Z, in cm^3, and the shear area A_t, in cm^2, for stiffeners submitted to lateral pressure are defined by the following formulae:

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

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

where:

m : Coefficient defined in Tab 11

p : Pressures, in kN/m^2, defined in Article [8].

Table 12 : Coefficients C_S and C_A

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

e : Ratio between permissible and actual hull girder longitudinal bending stresses (see [10.3]):
$e = \sigma_p / \sigma_{bl}$

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 [7.2].
Note 3: The ratio e is to be calculated at the section comprised between 0,3 · L and 0,7 · L at which e takes the highest value.

σ_{am}, τ_{am} : Permissible stresses, in N/mm², to be taken equal to:

- for bottom stiffeners submitted to impact pressure if occurring:
  - steel structures:
    $\sigma_{am} = 150/K$ (N/mm²)
    $\tau_{am} = 90/K$ (N/mm²)
  - aluminium alloy structures:
    $\sigma_{am} = 70/K$ (N/mm²)
    $\tau_{am} = 45/K$ (N/mm²).
- for other stiffeners contributing to the longitudinal strength (see [10.1]):
  - steel structures:
    $\sigma_{am} = 150\ C_S/K$ (N/mm²)
    $\tau_{am} = 90/K$ (N/mm²)
  - Aluminium alloys structures:
    $\sigma_{am} = 70\ C_A/K$ (N/mm²)
    $\tau_{am} = 45/K$ (N/mm²).
- for other stiffeners not contributing to the longitudinal strength:
  - steel structures:
    $\sigma_{am} = 150\ /K$ (N/mm²)
    $\tau_{am} = 90/K$ (N/mm²)
  - aluminium alloys structures:
    $\sigma_{am} = 70\ /K$ (N/mm²)
    $\tau_{am} = 45/K$ (N/mm²).

C_S, C_A : As defined in Tab 12.

These formulae are valid for stiffeners perpendicular to the plating or having an angle to the plating of less than 15°.

In the case of stiffeners having an angle α greater than 15° 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 (α).

The actual 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% of the span.

10.9.3 Minimum thicknesses

a) Steel stiffeners:

As a rule, for steel stiffeners, the thicknesses of web and flange are not to be less than:

- flat bar:

$$\frac{h_w}{t_w} \le 20\sqrt{k}$$

- other section:

$$\frac{h_w}{t_w} \le 55\sqrt{k}$$

$$b_f t_f \ge \frac{h_w t_w}{6}$$

for symmetrical flange:

$$\frac{b_f}{t_f} \le 33\sqrt{k}$$

or, for dissymmetric flange:

$$\frac{b_f}{t_f} \le 16,5\sqrt{k}$$

where:

h_w, t_w : Height and thickness of web, in mm

b_f, t_f : Width and thickness of face plate, in mm.

b) Aluminium alloy stiffeners:

As a rule, for aluminium alloy stiffeners, the thicknesses of web and flange are not to be less than:

- Flat bar:

$$\frac{h_w}{t_w} \le 15\sqrt{k}$$

- Other section:

$$\frac{h_w}{t_w} \le 33\sqrt{k}$$

$$b_f t_f \ge \frac{h_w t_w}{6}$$

for symmetrical flange:

$$\frac{b_f}{t_f} \le 21\sqrt{k}$$

or, for dissymmetric flange:

$$\frac{b_f}{t_f} \le 10, 5\sqrt{k}$$

where:

b_f, t_f : Width and thickness of face plate, in mm

h_w, t_w : Height and thickness of web, in mm.

10.9.4 Connection to primary members

a) In general, the resistant weld section A_w, in cm², connecting the ordinary stiffeners to the web of primary members, is not to be less than:

$$A_W = \varphi \cdot p \cdot s \cdot \ell \cdot K \cdot 10^{-3}$$

where:

K : Greatest material factor of ordinary stiffener and primary member, defined in Article [3]

ℓ : Span of ordinary stiffeners, in m

p : Pressure, in kN/m²

φ : Coefficient as indicated in Tab 13

s : Spacing of ordinary stiffeners, in m.

b) For aluminium alloys, when calculating the resistant connecting weld section, the fillet weld length d_e, in 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 mm

- case 2: for extruded T stiffeners, the lesser of:

  $d_e = b - 20$ and $d_e = 4\ t$

  where b, in mm, is the flange width of the extruded stiffener and t, in mm, is the web thickness of the extruded stiffener.

Table 13 : Coefficient φ

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

10.9.5 Bottom and bilge

a) Single and double bottoms are generally to be longitudinally framed

b) 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.

10.9.6 Side and front wall

For unprotected front walls located at the fore end, the pressure p_{sf} (see [8.6]) and allowable stresses are to be considered individually by the Society.

10.9.7 Deck

a) Where there are concentrated loads of significant magnitude, deck stiffeners are to be adequately strengthened

b) The ordinary stiffeners of decks constituting the top or bottom of tanks are also to comply with the requirements of [10.12]

c) 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.

10.9.8 Boundary walls of deckhouses

a) If unprotected front walls are located at the fore end, the pressure p_{su} (see [8.7]) and the allowable stresses are to be considered individually by the Society

b) 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

c) 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

d) 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.

10.9.9 Scantling of composite ordinary stiffeners

The scantling of ordinary stiffeners is to be checked according to:

- the local loads defined in Article [8]
- the safety factor criteria defined in [4.3]
- the calculation methodology defined in NR546 Composite ships, Section 7.

The general arrangements defined for steel and aluminium ordinary stiffeners are also applicable to composite ordinary stiffeners arrangements.

When deemed necessary by the Society, a combination with the longitudinal hull girder stresses for the local scantling under local loads may be carried out on a case-by-case basis.

10.10 Scantling of primary supporting members under local loads

10.10.1 General

The scantling of primary supporting members for steel and aluminium alloy structure are to be calculated according requirements defined from [10.10.2] to [10.10.7].

For composite structures, the scantling of primary stiffeners is to be checked according to [10.10.8].

The primary supporting members (floors, frames, beams) are to form continuous transverse frames.

10.10.2 Primary members submitted to lateral pressure

The section modulus Z, in cm³, and shear area A_t, in cm², required to support the design pressure 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.

p : Pressures, in kN/m², defined in Article [8]

σ_{am}, τ_{am} : Permissible stresses, in N/mm² to be taken equal to:

- for bottom primary stiffeners submitted to impact pressure if occurring:
  - steel structures:

    σ_{am} = 150/K (N/mm²)

    τ_{am} = 90/K (N/mm²)
  - aluminium alloy structures:

    σ_{am} = 70/K (N/mm²)

    τ_{am} = 45/K (N/mm²)
- for other primary stiffeners contributing to the longitudinal strength:
  - steel structures:

    σ_{am} = 150 C_S/K (N/mm²)

    τ_{am} = 90/K (N/mm²)
  - Aluminium alloys structures:

    σ_{am} = 70 C_A/K (N/mm²)

    τ_{am} = 45/K (N/mm²)
- for other stiffeners not contributing to the longitudinal strength:
  - steel structures:

    σ_{am} = 150 /K (N/mm²)

    τ_{am} = 90/K (N/mm²)
  - aluminium alloys structures:

    σ_{am} = 70 /K (N/mm²)

    τ_{am} = 45/K (N/mm²).

These formulae are applicable for single beam model calculation. Otherwise, the scantlings of reinforced structures are to be carried out by means of direct calculations with 2D or 3D beam model performed on the basis of criteria agreed upon with the Society.

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

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

10.10.3 Minimum thicknesses

a) Steel stiffeners:

As a rule, for steel stiffeners, the thicknesses of web and flange are not to be less than:

- web:

$$\frac{h_w}{t_w} \le 100\sqrt{k}$$

- face plate:
  - for symmetrical flange:

$$\frac{b_f}{t_f} \le 33\sqrt{k}$$

  - or, for dissymmetric flange:

$$\frac{b_f}{t_f} \le 16,5\sqrt{k}$$

b) Aluminium alloy stiffeners:

As a rule, for aluminium alloy stiffeners, the thicknesses of web and flange are not to be less than:

- web:

$$\frac{h_w}{t_w} \le 60\sqrt{k}$$

- face plate:
  - for symmetrical flange:

$$\frac{b_f}{t_f} \le 21\sqrt{k}$$

  - or, for dissymmetric flange:

$$\frac{b_f}{t_f} \le 10,5\sqrt{k}$$

Webs of primary supporting members are generally to be stiffened where the height, in mm, is greater than 60t (t being the web thickness, in mm, of the primary supporting member), by web stiffeners spaced not more than 65 t.

10.10.4 Floors and girders of single bottom

a) 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

b) 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

c) 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

d) In way of main machinery seatings, girders are to be positioned extending from the bottom to the foundation plate of main engines

e) 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^2, 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.

10.10.5 Sides and front walls

a) The section modulus and shear area of vertical primary supporting members of sides and front wall are to be calculated as defined in [10.10.2], taking into account the following permissible stresses:

σ_{am}, τ_{am} :

- Steel structures:

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

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

- Aluminium alloy structures:

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

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

σ_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} defined in [8.6] and allowable stresses are to be considered individually by the Society.

10.10.6 Decks

a) The primary members of decks constituting the top or bottom of tanks are also to comply with the requirements of [10.12]

b) When there are concentrated loads of significant magnitude (e.g. transmitted by pillars or other primary members or due to local loads, 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.

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

10.10.7 Deckhouse boundary walls

a) Where there is no access from inside deckhouse 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

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

10.10.8 Scantling of composite primary supporting members

The scantling of primary supporting members is to be checked according to:

- the local loads defined in Article [8]
- the safety factor criteria defined in [4.3]
- the calculation methodology defined in NR546 Composite ships, Section 7.

The general arrangements defined for steel and aluminium primary stiffeners are also applicable to composite primary stiffeners arrangements.

When deemed necessary by the Society, a combination with the longitudinal hull girder stresses for the local scantling under local loads may be carried out on a case-by-case basis.

10.11 Pillars

10.11.1 Actual compression load

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 r_w.

This weighting factor r_w depends on the relative position of each pillar with respect to that considered, and is to be taken 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^{th} pillar of the line, but not less than 0,478.

The compressive load Q is to be obtained, in kN, from the following formula:

$$Q = A_{PG}p + \sum r_w Q_C$$

where:

A_{PG} : Area of the deck acting on the pillar, in m^2

p : Deck load as defined in [8.8]

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

r_w : Weighting factor.

10.11.2 Steel pillars

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

- for $0 \le \lambda \le 1,5$

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

- for $\lambda > 1,5$

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

where:

λ : Slenderness of the pillar equal to the ratio between the pillar length, in m, and the minimum radius of gyration r of the pillar cross-section, in cm

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^4, of the pillar cross section

A : Area, in cm^2, of the pillar cross section.

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

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

where:

R_{eH} : Yield stress, in N/mm^2, of the steel considered.

As a rule, 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 intersections 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.

10.11.3 Pillars made of aluminium alloys

a) Critical stress for overall buckling of pillars.

For global buckling behaviour of pillars made of aluminium alloy, the critical stress, σ_c, in 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:

$R_{p\,0,2}'$: Minimum as-welded guaranteed yield stress of aluminium alloy used, in N/mm^2

f : Coefficient given in Tab 14 depending on the conditions of fixing of the pillar

ℓ : Length of pillar, in m

r : Minimum radius of gyration, in cm, of the pillar cross section, equal to:

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

C : Coefficient as given in Fig 10, and equal to:

- for alloys without heat treatment:

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

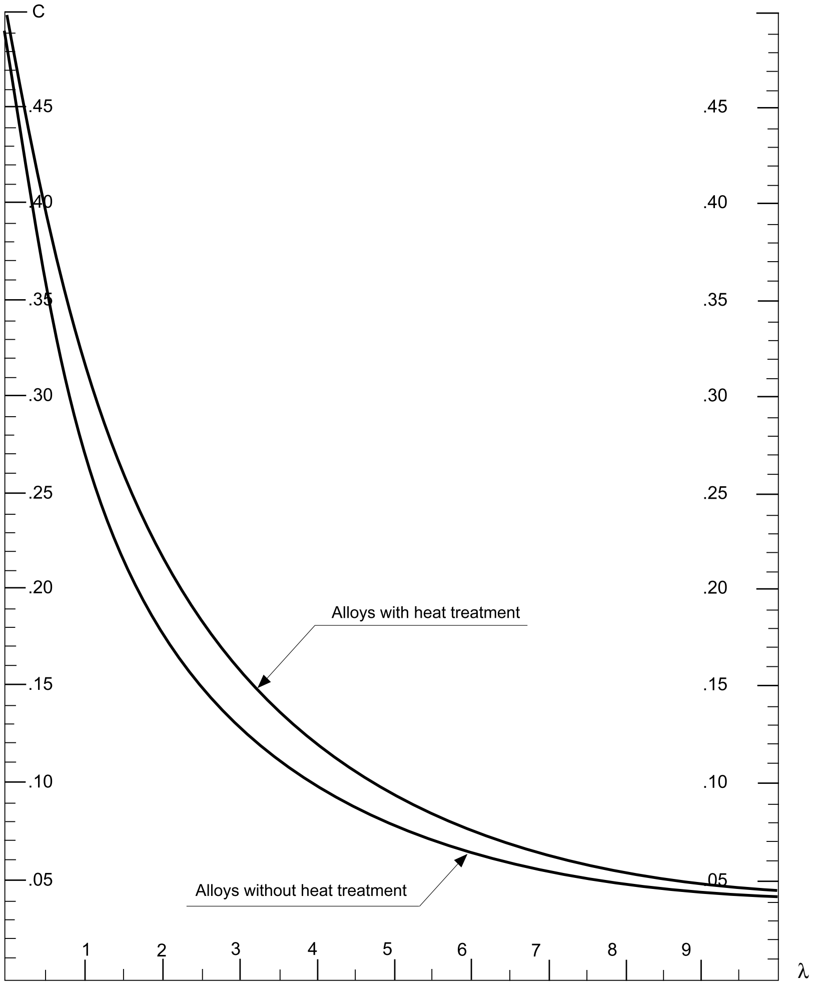
- for alloys with heat treatment:

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

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

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

Figure 10 : Coefficient C



I : Minimum moment of inertia, in cm^4, of the pillar cross section

A : Area, in cm^2, of the pillar cross section.

b) Critical stress for local buckling of pillars

- for local buckling behaviour of a pillars made of aluminium alloy, the admissible stress σ_{cl}, in N/mm^2, is given by the formula:

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

where:

C : Coefficient as defined in [10.11.3] a)

$R_{p\,0,2}'$: Minimum as-welded guaranteed yield stress of aluminium alloy used, in N/mm^2

σ_{El} : Stress defined below.

- for tubular pillars with a rectangular cross-section, the stress σ_{El}, in N/mm^2, 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 σ_{El}, in N/mm^2, 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 σ_{El}, in N/mm^2, 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:

b_f : Width of face plate, in mm

h_w : Web height, in mm

t_w : Web thickness, in mm

t_f : Thickness of face plate, in mm.

c) Scantlings of pillars

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

$\sigma \leq \sigma_c$

$\sigma \leq \sigma_{cl}$

where:

σ_c : Overall buckling critical stress, as defined in [10.11.3] a) above

σ_{cl} : Local buckling critical stress, as defined in [10.11.3] b) above

σ : Actual compressive stress, in N/mm², in the pillar equal to:

$\sigma = 10\ Q/A$

with:

A : Cross-sectional area, in cm², of the pillars

Q : Actual compression load, in kN, as defined in [10.11.1].

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

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

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

10.12 Tank bulkheads

10.12.1 General

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

10.12.2 Steel and aluminium structure

a) 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:

- for steel structures: $f_m = 0,80$
- for aluminium alloy structures: $f_m = 0,75$

p_t : Design pressure, in kN/m², as defined in [8.9]

σ_{am} :
- Steel structures:

  $\sigma_{am} = 185/K$ (N/mm²)
- Aluminium alloy structures:

  $\sigma_{am} = 85/K$ (N/mm²).

In addition, thickness is also to comply with [10.8.3].

b) Ordinary stiffeners:

The section modulus, shear area and welding section required for ordinary stiffeners are given by the formulae in [10.9.2], assuming:

m : Coefficient depending on the type of stiffener and support conditions at the ends of the stiffener span, to be taken according to Tab 11

p : Design pressure p_t as defined in [8.9]

σ_{am}, τ_{am} :
- Steel structures:

  $\sigma_{am} = 150/K$ (N/mm²)

  $\tau_{am} = 90/K$ (N/mm²)
- Aluminium alloy structures:

  $\sigma_{am} = 70/K$ (N/mm²)

  $\tau_{am} = 45/K$ (N/mm²).

c) Primary supporting members:

The section modulus, shear area and welding section required for horizontal and vertical primary supporting members are given by the formulae in [10.12.2] b), assuming:

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

p : Design pressure p_t as defined in [8.9]

σ_{am}, τ_{am} :
- Steel structures:

  $\sigma_{am} = 150/K$ (N/mm²)

  $\tau_{am} = 90/K$ (N/mm²)
- Aluminium alloy structures:

  $\sigma_{am} = 70/K$ (N/mm²)

  $\tau_{am} = 45/K$ (N/mm²).

d) Corrugated bulkheads:

The thickness and section modulus of corrugated bulkheads, calculated as stated in [10.12.2] to c) are to be increased by 10% and 20%, respectively.

The section modulus W_c, in cm³, of a corrugation may be derived from the following formula:

$W_c = d\ t\ (3\ b + c) / 6000$

where:

d, t, b and c:Dimensions, in mm, as shown on Fig 11.

In no case is the angle φ to be less than 40°.

Figure 11 : Dimensions of corrugation

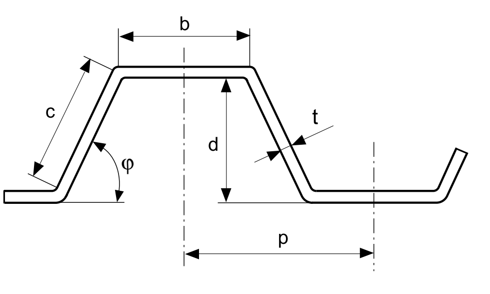
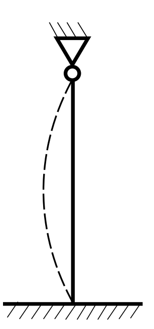
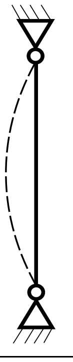
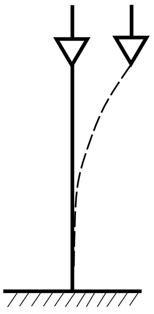
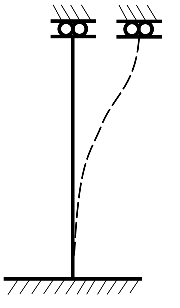
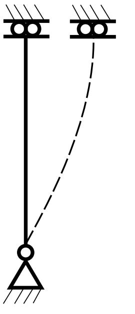


Table 14 : Coefficient f

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

10.12.3 Composite structure

The scantling of composite tank bulkheads is to be checked according to:

- for panel: [10.8.10]
- for ordinary stiffeners: [10.9.9]
- for primary supporting members: [10.10.8].

10.13 Subdivision bulkheads

10.13.1 Steel and aluminium structure

a) 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:
- for steel structures: $f_m = 0,75$
- for aluminium alloy structures: $f_m = 0,70$

p_{sb} : Design pressure, in kN/m², as defined in [8.10]

σ_{am} :
- Steel structures: $\sigma_{am} = 235/K$ (N/mm²)
- Aluminium alloy structures: $\sigma_{am} = 95/K$ (N/mm²).

The thickness of the collision bulkhead is to be multiplied by 1,15.

In addition, thickness is also to comply with [10.8.3].

b) Ordinary stiffeners:

The section modulus, shear area and welding section required for ordinary stiffeners are given by the formulae in [10.10.2], assuming:

m : Coefficient depending on the type of stiffener and support conditions at the ends of the stiffener span, to be taken according to Tab 11

p : Design pressure p_{sb} as defined in [8.10]

σ_{am}, τ_{am} :
- Steel structures:
  $\sigma_{am} = 210/K$ (N/mm²)
  $\tau_{am} = 120/K$ (N/mm²)
- Aluminium alloy structures:
  $\sigma_{am} = 95/K$ (N/mm²)
  $\tau_{am} = 55/K$ (N/mm²).

The section modulus, shear area and welding section required for the ordinary stiffeners of the collision bulkhead are to be calculated considering σ_{am} and τ_{am} divided respectively by 1,15 and 1,05.

c) Primary supporting members:

The section modulus, shear area and welding section required for horizontal and vertical girders are given by the formulae in [10.12.2], assuming:

m : Coefficient depending on support conditions at the ends of the girder span, generally to be taken equal to 10

p : Design pressure p_{sb} as defined in [8.10]

σ_{am}, τ_{am} :
- Steel structures:
  $\sigma_{am} = 210/K$ (N/mm²)
  $\tau_{am} = 120/K$ (N/mm²)
- Aluminium alloy structures:
  $\sigma_{am} = 95/K$ (N/mm²)
  $\tau_{am} = 55/K$ (N/mm²).

The section modulus, shear area and welding section required for the primary supporting members of the collision bulkhead are to be calculated considering σ_{am} and τ_{am} divided respectively by 1,3 and 1,2.

d) Corrugated bulkheads:

The thickness and section modulus of corrugated bulkheads, calculated as stated in [10.13.1], items a) to c) are to be increased by 10% and 20%, respectively.

The section modulus of a corrugation is to be calculated as indicated in [10.12.2] d).

e) Non-tight bulkheads:

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.

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 cm^3, given by the formula:

$Z = 2 \; s \; S^2$

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 bulkheads, and 3 mm for aluminium alloy bulkheads, and it is to be strengthened by vertical stiffeners.

f) Bulkheads which act as pillar:

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 cm^3, given by the formula:

$Z = 2{,}65 \; s \; S^2$

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 [10.11], the load supported being determined in accordance with the same provisions.

10.13.2 Composite subdivision bulkheads

The scantling of composite subdivision bulkheads is to be checked according to:

- for panel: [10.8.10]
- for ordinary stiffeners: [10.9.9]
- for primary supporting members: [10.10.8].

SECTION 3 OUTFITTINGS

1 Hull appendages

1.1 Propeller shaft brackets

1.1.1 General

Propeller shafting is either independent of the main hull and supported by shaft brackets (see [1.1.2]) or enclosed in bossing (see [1.1.3]).

1.1.2 Shaft brackets

As a rule, 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_{mb} : Minimum tensile strength, in N/mm², of the shaft bracket boss, with appropriate metallurgical temper

R_{ms} : Minimum tensile strength, in N/mm², of the propeller shaft.

Each arm of V-shaft brackets is to have a cross-sectional area, in mm², 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/mm², of arms, with appropriate metallurgical temper.

Single-arm shaft brackets are to have a section modulus at ship plating level, in cm³, not less than:

$$W = \frac{30}{R_{ma}} \cdot 10^{-3} \cdot \ell \cdot d_{so}^2 \cdot \sqrt{n \cdot d_{so}}$$

where:

ℓ : Length of the arm, in m, measured from the shell plating to the centreline of the shaft boss

n : Shaft revolutions per minute.

Moreover, the cross-sectional area of the arm at the boss is not to be less than 60% of the cross-sectional area at shell plating.

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 Tab 1indicates 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 : Loading cases

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)**

(1) To be checked under lateral pressure and against fatigue behaviour
(2) Buckling to be checked (100% of F_x transferred by built-in nozzle in case of thrust bearing aft of the stem)
(3) Ratio of M_y directly sustained by the built-in nozzle to be estimated on basis of relative stiffnesses
(4) Ratio of M_y directly sustained by the transom structure to be estimated on basis of relative stiffnesses
(5) Bolting calculation taking account of the actual pretension in bolts.

1.2.6 The stress criteria for static analysis may be taken as the following one, in N/mm²:

- 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:

f'_m : Coefficient depending on the material:
- 1,00 for steel structures
- 2,15 for aluminium alloy structures

K : Material factor defined in Sec 2, [3].

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.

1.2.10 Water jet tunnel in composite materials

The structure of water jet tunnel built in composite materials are to be examined accordingly the loading cases defined in this sub article taking into account the rule safety factors defined in Sec 2, [4.3].

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 2 and Fig 3. 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

A : Total area of rudder blade, in m², 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 m², of the rudder part abaft the centreline of rudder pintles

A_T : Area, in m^2, obtained by adding, to the rudder blade area, the area of rudder post or rudder horn, if any, up to height h

C_R : Rudder force, in N, acting on the rudder blade, as defined in [2.5]

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

k_1 : Shape factor, equal to:

$k_1 = (\Lambda + 2) / 3$

k_2 : Factor depending on rudder profile as 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:

- for rudders outside the propeller jet: $k_3 = 0,8$
- for rudders behind a fixed propeller nozzle: $k_3 = 1,15$
- in other cases: $k_3 = 1,0$

Λ : $\Lambda = h^2 / A_T$

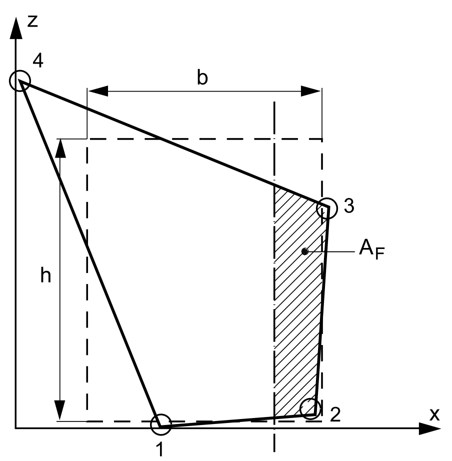
where h is the mean height of the rudder area, in m. In no case is the value of Λ to be greater than 2. Mean height h and mean breadth b of rudder blade are to be calculated according to Fig 1

Q_R : Rudder torque, in N · m, acting on the rudder stock, as defined in [2.5]

V_{AV} : Maximum ahead service speed, in knots, at maximum displacement, in still water

X_G : Distance, in m, from the centroid of area A to the centreline of pintles.

Figure 1 : Rudder geometry



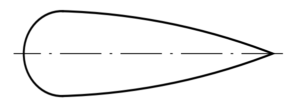
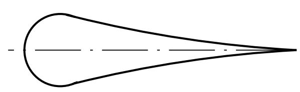
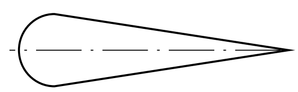
b : mean breadth of rudder, in m, equal to:

$$b = \frac{x_2 + x_3 - x_1}{2}$$

h : mean height of rudder, in m, equal to:

$$h = \frac{z_3 + z_4 - z_2}{2}$$

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^2.

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^2.

2.3.4 In the case of steels with a yield stress R_{eH} other than 235 N/mm^2, 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^2; in no case is R_{eH} to be greater than 450 N/mm^2 or 0,7 R_m, whichever is less

- for $R_{eH} > 235$ N/mm^2: $y = 0,75$
- for $R_{eH} \leq 235$ N/mm^2: $y = 1,0$

R_m : Minimum ultimate tensile strength of steel employed, in N/mm^2.

2.3.5 In general, significant reductions in rudder stock diameter for the application of steels with $R_{eH} > 235$ N/mm^2 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.

2.3.8 Rudder in aluminium alloys

For rudder built in aluminium alloys, the material factor k_1 to be taken into account in the scantling formulae is to be taken equal to:

$$k_1 = \frac{235}{R'_{lim}}$$

where:

R'_{lim} : Minimum yield stress of aluminium, in N/mm^2, as defined in Sec 2, [3.3.2].

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 · 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 $0,1 \cdot b$

α :
- For ahead condition: $\alpha = 0,33$
- For astern condition: $\alpha = 0,66$

b : Mean breadth of rudder area, in m, measured in accordance with Fig 1.

$k_A = A_F / A$

A_F being the area, in m^2, of the rudder blade portion afore the centreline of rudder pintles (see Fig 1).

2.6 Rudder stock

2.6.1 Rudder stock subject to torque

Rudder stock subject to torque are to have scantling such that the torsional stress, in N/mm^2, does not exceed the following value:

$\tau_{T\,ALL} = 68/K_1$

The rudder stock diameter is 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 stock subject to combined torque and bending are to have scantling such that their equivalent stress σ_e, in N/mm^2, does not exceed the value determined by the formula:

$\sigma_{e\,ALL} = 118 / K_1$

b) σ_e is given by the formula:

$$\sigma_e = \sqrt{\sigma_B^2 + 3 \cdot \tau_T^2}$$

where:

σ_B : Bending stress component, in N/mm^2, given by the formula:

$$\sigma_B = \frac{10,2 \cdot M}{d_{TF}^3} \cdot 10^3$$

τ_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:

$$d_{TF} = d_T \cdot \left(1 + \frac{4}{3} \cdot \left(\frac{M}{Q_R}\right)^2\right)^{1/6}$$

where:

H :
- For spade rudders (see Fig 2):
  $H = A_2 \cdot (H_C + H_2 / 2)$
- For rudders with 2 bearings (with solepiece) (see Fig 3):
  $H = A_1 \cdot a_1 \cdot u \cdot H1$

M : Bending moment, in N · m, which may be expressed as:

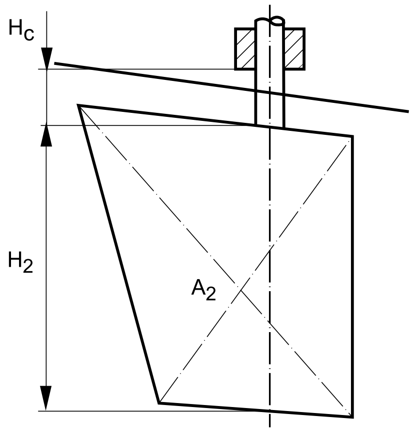
$M = 0,866 \cdot (C_R / A) \cdot H$

A_1, A_2, H_C, H_1 and H_2 are shown in Fig 2 and Fig 3.

The values of the coefficients a_1 and u are given in Tab 3 as a function of the ratio c, where:

$c = H_1 / (H_C + H_1)$

Figure 2 : Spade rudder



d) 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_T in way of the quadrant or tiller

e) 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:

$$M_B = C_R \cdot \left(\ell_{20} + \frac{\ell_{10} \cdot (2C_1 + C_2)}{3 \cdot (C_1 + C_2)}\right)$$

$$B_3 = M_B / \ell_{30}$$

$$B_2 = C_R + B_3$$

Figure 3 : Rudder with solepiece

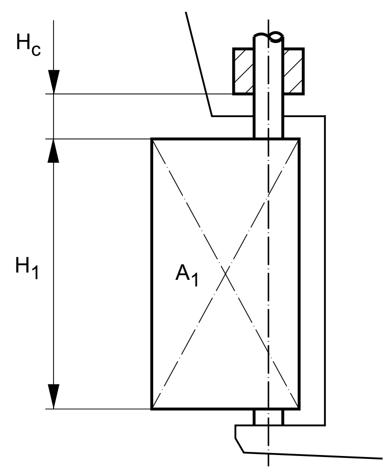


Table 3 : Coefficients a_1 and u

c	u	a_1	c	u	a_1
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

Figure 4 : Rudder with solepiece

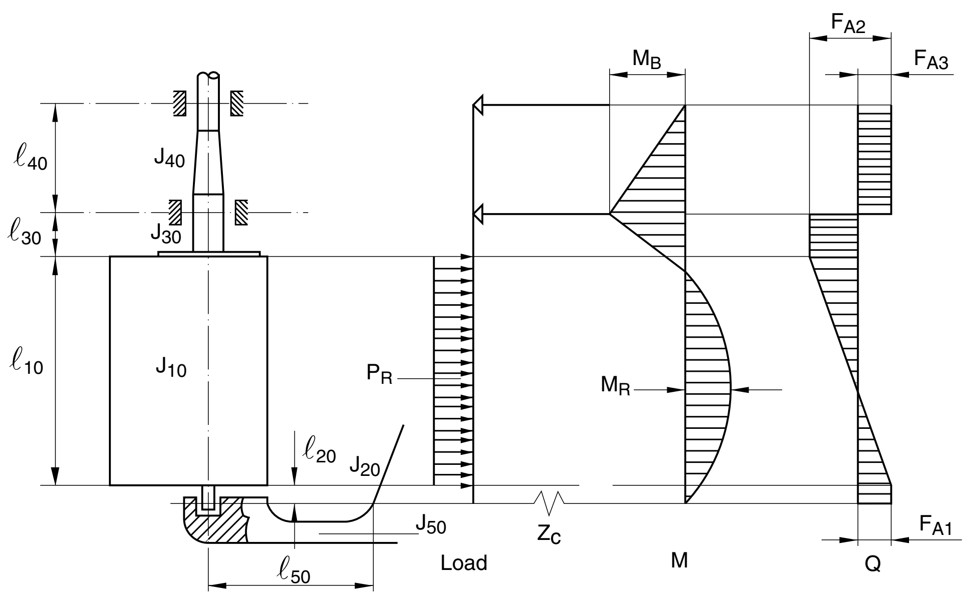
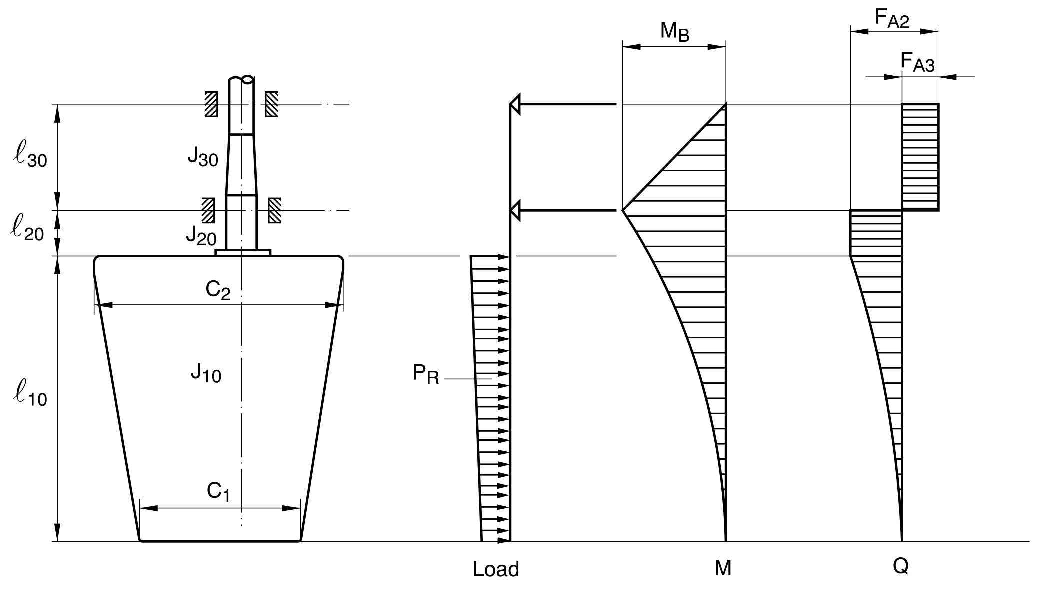


Figure 5 : Spade rudder



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 horizontal cross-section of the rudder plating is to be such that stress components, in N/mm², do not exceed the following values:

- normal bending stress:

  $\sigma_{Fl} = 110 / K_1$
- shear stress:

  $\tau = 50 / K_1$
- equivalent stress:

$$\sigma_e = \sqrt{\sigma_{Fl}^2 + 3 \cdot \tau^2} = \frac{120}{K_1}$$

2.7.3 The thickness of each rudder plate panel is to be not less than t_F, 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:

b_L : Major side of the plating panel, in m

s : Minor 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_F 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 m², 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 2, [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 2, [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/mm², is to 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.

Table 4 : Values of pressure

Bearing material	q_a (N/mm²)
Lignum vitae	2,5
White metal, oil lubricated	4,5
Synthetic material with hardness between 60 and 70 Shore D **(1)**	5,5
Steel, bronze and hot-pressed bronze-graphite materials **(2)**	7,0

(1) 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.
(2) Stainless and wear-resistant steel in combination with stock liner approved by the Society.

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:

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 FA is to be calculated from the following formula:

$$F_A = \frac{C_R}{A} \cdot A_G$$

where:

A_G : Part of the rudder blade area A, in m², supported by the pintle. A_G is to be not lower than:

$$A_G = A \cdot \frac{H_C + 0,5 \cdot H_1}{H_C + H_1}$$

C_R : Force, in N, acting on the rudder blade, determined as specified in [2.5].

Where direct calculation is used to obtain the rudder stock stress components, the value F_A is to be derived from the same calculation.

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:

$$d_B = 0,62 \cdot \frac{K_{1B}}{K_{1A}} \cdot \sqrt{\frac{d_1^3}{n_B \cdot e_M}}$$

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

where:

d_1 : Rule diameter d_T or d_{TF}, in mm, of the rudder stock, in compliance with the requirements in [2.6]

e_M : Mean distance, in mm, of the bolt axes from the longitudinal axis through the coupling centre

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 [2.3.4].

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 by 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).

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 cm^3, obtained by the formula:

$M_s = 0,43\ d_1^3\ 10^{-6}$

c) The thickness of the coupling flange is generally to be not less than d_B

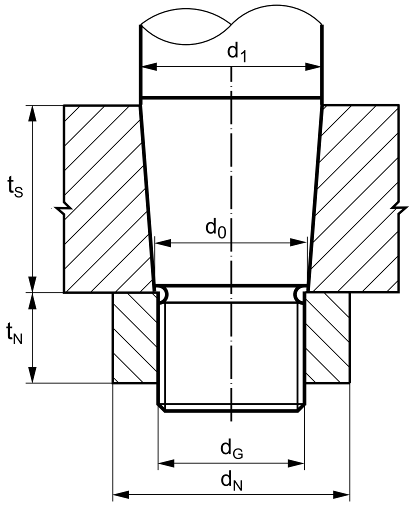
d) The distance of the bolt axes from the external edge of the coupling flange is generally to be not less than 1,2 d_B

e) A suitable locking device is to be provided to prevent the accidental loosening of nuts.

2.9.3 Cone couplings

Cone couplings of the shape shown in Fig 6 are to be secured by a slugging/hydraulic nut, as the case may be, provided with an efficient locking device, and with the dimensions defined in the present requirements.

Figure 6 : Cone coupling geometry



The dimensions of the locking nut are given for guidance only, the determination of adequate scantlings being left to the responsibility of the designer.

a) Dimensions of cone couplings with hydraulic arrangements for assembling and disassembling the coupling:

Taper: $1/20 \leq (d_1\text{-}d_0) / t_S \leq 1/12$

$t_S \geq 1,5\ d_1$

$d_G \geq 0,65\ d_1$

$t_N \geq 0,60\ d_G$

$d_N \geq 1,2\ d_0$ and, in any case, $d_N \geq 1,2\ d_G$

A washer is to be fitted between the nut and the rudder gudgeon not less than 0,13 d_G in thickness, and with an outer diameter not less than 1,3 d_0 or 1,6 d_G, whichever is greater.

When no key is provided in cone couplings, the designer is to provide the Society with shrinkage calculations supplying all data necessary for the appropriate check.

b) Dimension of cone couplings without hydraulic arrangements for assembling and disassembling the coupling:

Taper: $1/12 \leq (d_1\text{-}d_0) / t_S \leq 1/8$

$t_S \geq 1,5\ d_1$

$d_G \geq 0,65\ d_1$

$t_N \geq 0,60\ d_G$

$d_N \geq 1,2\ d_0$ and, in any case, $d_N \geq 1,2\ d_G$.

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.

c) Instructions:

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 not less than the rudder stock diameter. For spade rudders, the lower third may taper down to 0,75 times the stock diameter.

2.10.2 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.

2.10.3 The thickness of the arms is to be not less than the blade thickness; the section modulus, in cm^3, of the 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_1 : 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 It is assumed in this Sub article 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 EN 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 hold 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 ≤ 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 and [3.6.1]
   - when two bow anchors are fitted, the mass of each anchor, the diameter and the length of each chain cable are to comply with Tab 5.

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:

   A : Area, in m², 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 2, [2.4] and with a breadth greater than B/4

   a : Distance, in m, from summer load waterline amidships to the upper deck at side

   Δ : Maximum displacement, in t

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 2, [2.4]

Θ_i : Angle of inclination aft of each front bulkhead, as shown on Fig 7.

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

The anchors are to be of an approved type and satisfy the testing conditions laid down in NR216 Materials and Welding.

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 Tab 5
- 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.

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.

Figure 7 :

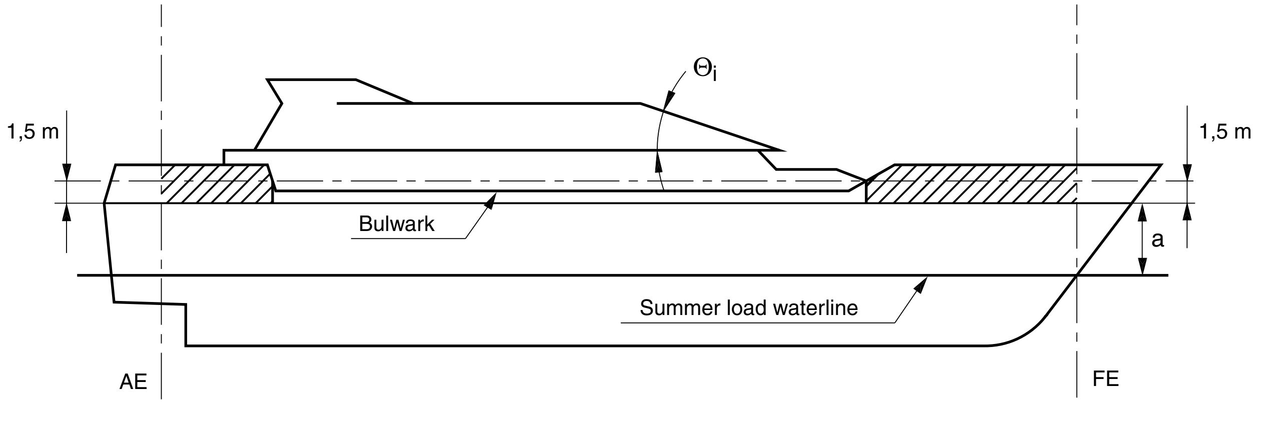


Table 5 : Equipment

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.

3.6.4 Chain cables

a) 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 NR216 Materials and Welding

b) Normally grade Q2 or grade Q3 stud link chain cables are to be used with HHP and VHHP anchors

c) Proposal for use of grade Q1 chain cables connected to ordinary anchors will be specially considered by the Society

d) For crew boat with an Equipment Number EN ≤ 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:
  - Class M (4) [grade 400], i.e. grade SL2 as defined in NR216 “Materials and Welding”, in lieu of grade Q2
  - Class P (5) [grade 500], i.e. grade SL3 as defined in NR216 “Materials and Welding”, in lieu of grade Q3.

- equivalence in strength is to be based on proof load
- the studless chain cable meets the requirements of the Society.

e) 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 Tab 5:

- 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:

  $PL_3 = 13{,}73 \cdot d^2 \cdot (44 - 0{,}08 \cdot d) \cdot 10^{-3}$

  $BL_3 = 2 \cdot PL_3$

f) 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

g) 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

a) Steel wire ropes may be used as an alternative to stud link chain cables required in Tab 5 when EN ≤ 500, provided that the following requirements are complied with

b) The length L_{swr} in m, of the steel wire rope is to be not less than:

- when EN ≤ 130:

  $L_{swr} = L_{ch}$

- when 130 < EN ≤ 500:

  $L_{swr} = L_{ch} \cdot (EN + 850) / 900$

where L_{ch} is the length of stud link chain cable required by Tab 5

c) 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

d) The breaking load, in kN, of the chain cable diameters 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 Tab 5 corresponding respectively to grade Q2 and grade Q3 chain cables

e) 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

a) Synthetic fibre ropes may be used as an alternative to stud link chain cables required in Tab 5 when EN ≤ 130, provided that the following requirements are complied with

b) Fibre ropes are to be made of polyamide or other equivalent synthetic fibres, excluding polypropylene

c) The length L_{sfr}, in m, of the synthetic fibre rope is to be not less than:

- when EN ≤ 60:

  $L_{sfr} = L_{ch}$

- when 60 < EN ≤ 130:

  $L_{sfr} = L_{ch} \cdot (EN + 170)/200$

where L_{ch} is the length of stud link chain cable required by Tab 5

d) 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)

e) 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

a) The windlass is to be power driven and suitable for the size of chain cable, and is to have the characteristics stated below

b) 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

c) 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.

d) 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).

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.

f) 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

g) 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 2, 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.

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