NR500 DT R03 NOVEMBER 2022

RULES FOR THE CLASSIFICATION AND THE CERTIFICATION OF **YACHTS**

NR500 – NOVEMBER 2022

YACHTS

BUREAU VERITAS

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This version of the document takes precedence over previous revision. Unless otherwise specified, Part A of these rules applies from November 1, 2022. Unless otherwise specified, Parts B and C of these rules apply to ships for which contract for construction is signed on or after November 1, 2022. The Society may refer to the contents hereof before November 1, 2022, as an when deemed necessary or appropriate.

The official version of the Rules for the Classification of Steel Ships is available at the Bureau Veritas Marine & Offshore website: https://marine-offshore.bureauveritas.com/

These Rules are provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467 "Rules for the Classification of Steel Ships". The current version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

PART A

CLASSIFICATION AND SURVEYS

PART B

HULL AND STABILITY

PART C

MACHINERY, ELECTRICITY, AUTOMATION AND FIRE PROTECTION

REFERENCE DOCUMENT

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NR500

RULES FOR THE CLASSIFICATION AND THE CERTIFICATION OF YACHTS

Part A	Classification and Surveys
Part B	Hull and Stability
Part C	Machinery, Electricity, Automation and Fire Protection

November 2022

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RULES FOR THE CLASSIFICATION AND THE CERTIFICATION OF YACHTS

Part A
Classification and Surveys

Chapter 1 General

Part A
Classification and Surveys

CHAPTER 1
GENERAL

Section 1 Application and Definitions

Symbols

L : Rule length, in m, defined in Pt B, Ch 1, Sec 2, [2.2.1].

1 General

1.1 Application

1.1.1 This Rules Note provides the requirements for the classification and certification of yachts.

The wording currently used in the present Rules is:

- yacht: Generic term including pleasure cruising yachts not engaged in trade or engaged in trade
- **yacht**: Yacht not engaged in trade as defined in Ch 1, Sec 2
- **charter yacht**: Yacht engaged in trade as defined in Ch 1, Sec 2.

The general conditions of classification are laid down in the Marine & Offshore General Conditions.

1.1.2 The requirements of these Rules cover sailing yachts and motor yachts, of monohull type or catamaran type, built in steel, aluminium, composite materials, wood (strip planking or plywood) or High Density Polyethylene (HDPE).

Note 1: Traditional wooden yachts are to be considered on a case by case basis.

1.1.3 The application criteria of the different parts of the present Rules are the following:

- Part A - Classification and Surveys, applies to all yachts

  (see Ch 1, Sec 2 for classification principles and maintenance of class and Ch 1, Sec 3 for certification principles)
- Part B - Hull and Stability, applies to all yachts not exceeding 90 m in length, unless otherwise specified
- Part C - Machinery and Systems, applies to all yachts unless otherwise specified

1.1.4 Yachts exceeding 90 m in Rule length

Yachts exceeding 90 m in Rule length are considered by the Society on the basis of NR467 Rules for the Classification of Steel Ships and the present Rules.

1.1.5 Charter Yacht carrying more than 36 passengers

Charter Yacht as defined in Ch 1, Sec 2 carrying more than 36 passengers are considered by the Society on the basis of NR467 Rules for the Classification of Steel Ships.

1.1.6 Racing yachts

As a rule, the requirements of these Rules do not cover racing yachts.

1.2 Special consideration

1.2.1 The Society will consider alternatives to the provisions of the Rules provided that they can be demonstrated, through satisfactory service experience or sound engineering analysis, to be equivalent to the safety standards set forth in the present Rules.

1.2.2 The regulations set forth in the present Rules apply to yachts operated in a proper manner by competent and qualified crew according to the environmental, operating and other criteria on which classification and/or certification is based.

1.2.3 The Society will consider the classification and/or certification of yachts incorporating novel design principles or features, to which the provisions of the Rules are not directly applicable, on the basis of experiments, calculations or other supporting information provided to the Society.

1.2.4 Other rules of the Society

In the present Rules Note, the references to other Rules of the Society are defined in Tab 1.

Table 1 : Reference to other Rules of the Society

Reference	Title
NR467	Rules for the Classification of Steel Ships
NR600	Hull structure and arrangements for the classification of cargo ships less than 65 m and non cargo ships less than 90 m
NR546	Hull in Composite, Plywood and High Density Polyethylene
NR561	Hull in Aluminium Alloys, Design Principles, Construction and Survey
NR216	Rules on Materials and Welding for the Classification of Marine Units

2 National and International Regulations

2.1 General

2.1.1 The classification and/or the certification of a yacht according to the present Rules Note does not relieve the Interested Party (Shipowner, Building Yard or Designer) from compliance with any requirements issued by the Flag Administrations (national rules or International Conventions e.g. Load Line, Solas, Marpol as defined in [3.2]).

2.1.2 When authorised by the Flag Administration concerned, the Society will act on its behalf within the limits of such authorisation. In this respect, the Society will take into account the relevant National Requirements, carries out surveys during construction, reports and issues or contributes to issue the corresponding certificate.

The above surveys do not fall within the scope of the classification and/or certification of yachts, even though their scope may overlap in part and may be carried out concurrently with surveys for assignment, maintenance of class or certification.

2.1.3 In the case of a discrepancy between the provisions of the applicable international and national regulations and those of the present Rules, normally the former take precedence over the latter. However, the Society reserves the right to call for the necessary adaptation to preserve the intention of the present Rules.

2.1.4 Upon request of the Interested Party as defined in [3.1] and with agreement of the Flag Administration, the Society may accept other requirements considered as equivalent, on a case by case basis.

2.1.5 Charter yacht carrying more than 12 (and less than 36) passenger

The requirements and arrangements of the present Rules for **Charter yacht** as defined in Ch 1, Sec 2 and carrying more than 12 (and less than 36) passengers within the scope of classification and/or certification may be different from requirements of international conventions (in particular Solas).

The Flag Administration may request that international convention or national regulations be applied instead of the present requirements.

2.1.6 Yacht under 300 UMS not engaged in trade

The requirements and arrangements of the present Rules for yacht under 300 UMS not engaged in trade, within the scope of classification and/or certification, may be different from requirements issued by the Flag Administration.

The Flag Administration may request that national regulations be applied or recommended instead of the present requirements.

3 Definitions

3.1 Definitions used in the present Rules

3.1.1 The general definitions used in the present Rules are given hereafter:

- Administration:
  Government of the State whose flag the yacht is entitled to fly.
- International Rules:
  International Rules and Regulations used by Administrations as referential, partly or in full (see [3.2.1]).
- National Rules:
  Set of Rules and Regulations of a Flag Administration applicable for the registration of a yacht by this Flag Administration.
- Rules:
  The present set of Rules and documents issued by the Society serving the same purpose.
- Society:
  The Classification Society with which the yacht is classed.
- Interested Party:
  Party, other than the Society, having responsibility of the classification and/or certification of the yacht, such as the Owner or his representatives, or the Shipbuilder, or the engine Builder, or the Supplier of parts to be tested.

3.2 Definitions used in the International Rules

3.2.1 The International Rules are mainly:

- Load Line Convention:

  International Convention on Load Lines, 1966, as amended
- Solas Convention:

  International Convention for the Safety of the Life at Sea, 1974, as amended
- Marpol Convention:

  International Convention for the Prevention of Pollution from Ships, 1973, as amended
- EC Directive:

  Directive 2013/53/EU issued by the European Council dated June 16th, 1994, as amended.

3.2.2 The main definitions used in the International Rules are given hereafter:

- Passenger:

  Every person other than the master and the members of the crew or other persons employed or engaged in any capacity on board the ship on the business of that ship, or a child under one year old
- Passenger ship:

  Ship which carries more than 12 passengers
- Cargo ship:

  Any ship which is not a passenger ship
- Length according to the International Convention on Load Line (L_{LL}):

  This length is equal to 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the fore side of the stem to the axis of the rudder stock on that waterline, if that be greater. In yachts designed with a rake of keel, the waterline on which this length is measured shall be parallel to the design water line.
- Length according to EC Directive (L_h):

  This length is to be measured parallel to the reference waterline and yacht centerline as the distance between two vertical planes, perpendicular to the centreplane of the yacht, one plane passing through the foremost part and the other through the aftermost part of the yacht.

  This length includes all structural and integral parts of the yacht, such as wooden, plastic or metal stems or sterns, bulwarks and hull/deck joints.

  This length excludes parts which are normally fixed, such as fixed spars, bowsprits, pulpits at either end of the yacht, stemhead fittings, rudders, outboard motor brackets, outdrives, waterjets and any propulsion units extending beyond the transom, diving and boarding platform, rubbing strakes and permanent fenders. Outdrives, waterjets, other propulsion units and all movable parts shall be measured in their normal operating condition to their maximum lengthwise extension when the craft is underway.

  This length excludes outboard motors and any other type of equipment that can be detached without the use of tools.
- Gross tonnage:

  Gross tonnage as calculated according to Annex 1 of the International Convention on Tonnage Measurement of Ships, 1969, as amended.

4 Rules cumulative effects

4.1 Application

4.1.1 Tab 2, Tab 3 and Tab 4 suggest for information only the cumulative effect of the several national and international regulations and the present Rules Notes.

For guidance, these tables indicate the possible additional requirements (national rules or international rules) that may be requested by the Flag Administration as follow:

- Tab 2 applies to yachts having the service notation **yacht**
- Tab 3 applies to yachts having the service notation **charter yacht** and carrying not more than 12 passengers
- Tab 4 applies to yachts having the service notation **charter yacht** and carrying more than 12 passengers.

Note 1: **Yacht** and **charter yacht** are defined in Ch 1, Sec 2.

Table 2 : Service notation Yacht

Type of hull	Monohull or multihull			
Hull materials	Steel or aluminium or composites or wood or HDPE			
Length according to EC directive (L_h)	≤ 24 m		> 24 m	
Gross tonnage	< 400 GRT			≥ 400 GRT
Number of passengers	All			
Classification Rules	Present Rules			
Regulatory framing:	when State is EC member	when State is not EC member	whatever State	
• National **(1)**	EC Directive	National Rules	National Rules	National Rules
• International (indicated as reference) **(2)**	Marpol Annexes IV to VI	Marpol Annexes IV to VI	Marpol Annexes IV to VI	Marpol Annexes I, IV to VI

(1) National Rules may supersede the International regulatory framing or may consider totally or partly the International regulatory framing.
(2) Marpol Annex IV is only applicable to yachts carrying more than 15 persons.

Table 3 : Service notation Charter yacht when carrying not more than 12 passengers

Type of hull	Monohull or multihull			
Hull materials	Steel or aluminium or composites or wood or HDPE			
Loadline length according to International Rules	≤ 24 m	> 24 m		
Gross tonnage	< 400 GRT		≥ 400 GRT and < 500 GRT	≥ 500 GRT
Classification Rules	Present Rules			
National regulatory framing	National Rules	National Rules	National Rules	National rules
International regulatory framing (indicated as reference) **(1)**	Marpol Annexes IV to VI	Loadline + Marpol Annexes IV to VI	Loadline + Marpol Annexes I, IV to VI	Loadline + Marpol Annexes I, IV to VI + Solas for Cargo ships

(1) Marpol Annex IV is only applicable to yachts carrying more than 15 persons.

Table 4 : Service notation Charter yacht when carrying more than 12 passengers

Type of hull	Monohull or multihull			
Hull materials	Steel or aluminium or composites or wood or HDPE			
Loadline length according to International Rules	≤ 24 m	> 24 m		
Gross tonnage	< 400 GRT		≥ 400 GRT and < 500 GRT	≥ 500 GRT
Classification Rules	Present Rules **(1)**			
National regulatory framing	National Rules	National Rules	National Rules	National rules
International regulatory framing (indicated as reference) **(1)** **(2)**	Marpol Annexes IV to VI + Solas for Passenger ships	Loadline + Marpol Annexes IV to VI + Solas for Passenger ships	Loadline + Marpol Annexes I and IV to VI + Solas for Passenger ships	Loadline + Marpol Annexes 1 and IV to VI + Solas for Passenger ships

(1) See [2.1.5].
(2) Marpol Annex IV is only applicable to yachts carrying more than 15 persons.

Section 2 Classification and Surveys

1 Principles of classification

1.1 General

1.1.1 The classification process consists of:

- the development of Rules, guidance notes and other documents relevant to the ship, structure, material, equipment, machinery and other items covered such documents
- the review of plans and calculations, and the surveys, checks and tests intended to demonstrate that the ship meets the Society's Rules
- the assignment of class and issue of a Certificate of Classification, where compliance with the present Rules is found
- the periodical, occasional and class renewal surveys performed to record that the ship in service meets the conditions for maintenance of class.

1.1.2 The general principles of classification are defined in NR467 Steel Ships, Pt A, Ch 1, Sec 1.

2 Classification notations

2.1 General

2.1.1 The classification notations give the scope according to which the class of the yacht has been based.

The type of classification notations assigned to a yacht are the following:

- class symbol
- construction marks
- service notations with additional service features, as applicable
- navigation notations
- additional class notation (optional).

2.2 Class symbols and construction marks

2.2.1 Class symbol

The class symbol are assigned as indicated in NR467 Steel Ships, Pt A, Ch 1, Sec 2, [2].

2.2.2 Construction marks

The construction marks are assigned separately to the hull and the machinery installation as indicated in NR467 Steel Ships, Pt A, Ch 1, Sec 2, [3].

Note 1: Ships assigned with the service notation **yacht** or **charter yacht** according to [2.3.1] a) and having a length less than 24 m may be assigned the construction mark only placed before the symbol **HULL** when the machinery installations are not surveyed for classification. No symbol **MACH** is granted in this case.

2.3 Service notations

2.3.1

a) Service notation:

The service notations **yacht** or **charter yacht** define the type and/or service of the yacht which have been considered for its classification, according to the request for classification signed by the Interested Party, as follows:

- **yacht** for ships intended for pleasure cruising not engaged in trade
- **charter yacht** for ships intended for pleasure cruising, engaged in trade, e.g hired with a crew

Note 1: Yachts hired without crew are not considered as engaged in trade.

Note 2: A yacht alternately engaged in trade and not engaged in trade is to be considered with the service notation **charter yacht**.

b) Additional services features:

The service notation is always to be completed by the following additional service features:

- motor or sailing:
  - **motor** for ships propelled by a propulsion engine
  - **sailing** for ships fitted with a sail propulsion, including those assisted by auxiliary engine propulsion

- hull material:
  - **C** when the hull is made of composite material or HDPE
  - **S** when the hull is made of steel material
  - **A** when the hull is made of aluminium material
  - **W** when the hull is made of wood material.

2.4 Navigation notations

2.4.1 General

a) List of navigation notations:

Every classed yacht is to be assigned one navigation notation as follows:

- The navigation notation **unrestricted navigation** is assigned to a yacht intended to operate in any area and during any period of the year.
- The navigation notation **navigation limited to 60 nautical miles** is assigned to a **charter yacht** under 300 UMS intended to operate only within 60 nautical miles from the shore.

  The designation of the sea condition and the indication of any exemptions are defined in the Annex to the certificate of classification.

Note 1: At Interested Party request and on a voluntary basis, the navigation notation **navigation limited to 60 nautical miles** can be assigned to a **yacht** under 300 UMS.

- The navigation notation **coastal area** is assigned to a yacht intended to operate only within 20 nautical miles from the shore and with a maximum sailing time of six hours from a port of refuge or safe sheltered anchorage.
- The navigation notation **sheltered area** is assigned to a yacht intended to operate in sheltered waters, i.e. harbours, estuaries, roadsteads, bay, lagoons and generally calm stretches of water and when the wind force does not exceed 6 Beaufort scale.

b) The assignment of a navigation notation, including the reduction of scantlings or specific arrangements for restricted navigation notation, is subject to compliance with the requirements laid down in Part B and Part C.

c) The assignment of a navigation notation does not absolve the Interested Party from compliance with any International or National regulations established by the Administrations for a ship operating in national waters, or a specific area, or a navigation zone.

2.5 Additional class notations

2.5.1 An additional class notation expresses the classification of additional equipment or specific arrangement.

Additional class notation may be assigned by the Society on request of the Interested Party applying for classification as indicated in NR467 Rules for Steel Ships, Pt A, Ch 1, Sec 2, [6].

The following specific additional class notations dedicated to yachts may be assigned: as an example:

a) **STAB-WIND**:

The additional class notation **STAB-WIND** may be assigned only to yacht having service notation **yacht** or **charter yacht** satisfying the intact stability and weather criterion as defined in Pt B, Ch 3, Sec 2, [3].

The attention of the Interested Party is drawn to the fact that the flag Administration may impose an intact stability and weather calculation.

b) **WPS1** or **WPS2**:

At the request of the Interested Party, the additional class notation **WPS1** or**WPS2** may be assigned to sailing yachts.

The requirements for the assignment of these notations are given in NR206 Classification of Wind Propulsion Plants on Board Ships.

The attention of the Interested Party is drawn to the fact that the flag Administration may impose specific recommendations.

c) **COMF+**:

The additional class notation high comfort level with regard to noise **COMF+** is assigned to yachts satisfying levels of noise defined in NR467 Steel Ships, Pt F, Ch 6, Sec 5.

The requirements of notations **COMF-NOISE** as defined in NR467 Steel Ships, Pt A, Ch 1, Sec2 [6.7.2] have to be fulfilled prior to assigning the notation **COMF+**.

This notation **COMF+** deals with additional criteria in view to evaluate higher standard comfort level than **COMF-NOISE**. These additional criteria are to be selected among the following performance indexes:

- Sound insulation index
- Impact index
- Emergence
- Intermittent noise
- Intelligibility.

The additional class notation **COMF+** is to be completed by the selected performance indexes.

Example:

COMF + /Impact index /Intermittent noise /Intelligibility

d) helicopter facilities (**HEL(Y**):

The additional class notation **HEL(Y)** may be assigned to yachts fitted with helicopter facilities.

The requirements for the assignment of this notation are given in Pt B, Ch 5, Sec 2, [9.8] or Pt B, Ch 6, Sec 2, [7.8].

3 General requirements for assignment, maintenance, suspension and withdrawal of class

3.1 Assignment of class

3.1.1 The assignment of class for new building yacht or yacht classed after construction are defined in NR467 Steel Ships, Pt A, Ch 2 Sec 1.

The Certificate of Classification is issued according to NR467 Rules for Steel Ships, Pt A, Ch 2, Sec 2, [3].

3.2 Maintenance of class

3.2.1 Classed yachts are submitted to the following surveys for the maintenance of class:

- annual
- intermediate
- class renewal
- bottom
- tailshaft

The intervals at which the surveys are carried out and the procedures related to surveys are defined in NR467 Steel Ships, Pt A, Ch 2, Sec 2.

3.3 Suspension and withdrawal of class

3.3.1 The class may be discontinued either temporally or permanently as defined in NR467 Steel Ships, Pt A, Ch 2, Sec 3.

4 Survey for new construction

4.1 Hull survey for new construction

4.1.1 When a hull construction is surveyed by the Society the Shipbuilder is to provide all appropriate evidence required by the Society that the hull is built in compliance with the rules and regulations according to:

- Pt B, Ch 5, Sec 11 for hull built in steel or aluminium alloys
- Pt B, Ch 6, Sec 1, [4] for hull built in composite, plywood or HDPE materials.

5 Hull survey for maintenance of class

5.1 Annual survey

5.1.1 The requirements for annual surveys are defined in NR467 Steel Ships, Pt A, Ch 3, Sec 1.

Ships assigned with the service notation **yacht** and having a length less than 24 m are not submitted to annual surveys for hull and machinery.

5.2 Intermediate survey

5.2.1 The requirements for intermediate surveys are defined in NR467 Steel Ships, Pt A, Ch 3, Sec 2.

For yacht of less than 24 m in length with the service notation **yacht**, the intermediate survey is applicable at any period of class.

The survey is to include:

a) For hull and hull equipment:
   - superstructures, coachroofs, hatches, companionways, ventilator and air pipe coamings, skylights, flush deck scuttles and other openings
   - all closing appliances which protect openings in the deck
   - hull side openings with their securing appliances
   - freeing port shutters provided in bulwarks
   - anchors, chain cables and windlasses
   - fastenings, including those through the ballast keel, as far as possible

- structural reinforcements in way of masts and chain plates
- hull condition in way of openings.

Testing of the above is to be carried out as appropriate.

The steering gear arrangement is to be examined and tested including its associated equipment and control systems.

b) For machinery and systems:

Ships assigned with the service notation **yacht** and having a length less than 24 m are submitted to a survey which scope is as indicated in NR467 Steel Ships, Pt A, Ch 3, Sec 1 [3].

5.3 Class renewal survey

5.3.1 The requirements for class renewal surveys are defined in NR467 Steel Ships, Pt A, Ch 3, Sec 3.

The following additional requirements are to be considered for yachts built with hull materials other than steel:

a) Yachts with additional service feature **C**:

For yachts built in composite materials, an external examination of the coating condition is to be carried out. This examination is to be directed at discovering significant alteration of the coating or contact damages.

b) Yachts with additional service feature **W**:

For yachts built with laminate wood and provided with coating, an external examination of the protection of edges against water ingress is to be carried out.

For ships built with plank seams and butts, the condition of plank seams, butts and caulking is to be externally examined and renewal is to be carried out as found necessary by the Surveyor.

Where applicable, the timber of the main structural items is to be tapped specially in place where ventilation is poor. When traces of worm or rot are found, the damaged pieces are to be added to sound wood or renewed as found necessary by the Surveyor.

c) Yachts with additional service feature **A**:

For yachts built in aluminium alloy, the highly stressed areas are to be externally examined and dye penetrant checks are to be carried out, as found necessary by the Surveyor.

Thickness measurements are to be carried out, in areas where chaffing or corrosion may have developed, as found necessary by the Surveyor.

5.4 Bottom survey

5.4.1 The requirements for bottom surveys are defined in NR467 Steel Ships, Pt A, Ch 3, Sec 4.

The following additional requirements are to be considered for yachts built in wood or in aluminium alloys:

a) Yachts with additional service feature **W**:

The seams and butts of the garboard and bilges at midship, the keel scarphs and rabbets are to be examined. The same applies to caulking of the underwater parts specially butts and rabbets. The Surveyor may require caulking to be renewed or the hull to be recaulked as found necessary.

For hulls built with planks, a particular attention is to be given to the tightness of the junctions between planks.

The condition of the bolting and fastening and, in general, of metal parts, is to be examined.

If decay or rot is found or if the wood is worn, it is to be renewed as found necessary by the Surveyor.

Where the planking is sheated with composite material, such as fibre reinforced plastic, the edges of planks are to be examined as found necessary by the Surveyor, in order to ascertain that no ingress of water has occurred along them.

b) Yachts with additional service feature **A**:

For yachts built in aluminium alloy, the appendages of the hull (hydrofoils, hydrofoil supports, skirt fixations, shaft brackets, as applicable) are to be examined as found necessary by the Surveyor, with particular attention to their fixation to the hull and to the surrounding area specially where deterioration of the hull protection is found.

5.5 Tailshaft survey

5.5.1 The requirements for tailshaft surveys are defined in NR467 Steel Ships, Pt A, Ch 3, Sec 5.

6 Survey related to additional class notation

6.1 Scope of survey

6.1.1 Details on the scope of surveys of specific equipment and systems fitted on board the ship, which are covered by an additional class notation within the scope of the maintenance of the relevant additional class notation are defined in NR467 Steel Ships, Pt A, Ch 5.

Section 3 Certification

1 Society's certification scheme

1.1 Certification process

1.1.1 The certification process consists of:

- the review of plans and calculation,
- construction survey,
- tests deemed necessary by the Society or provided by the Interested Party (Owner, Shipbuilder, Supplier)
- issuance of an attestation or reports attesting the full or partial compliance of the yacht and/or its components with the present Rules Note.

1.2 Alternative survey scheme

1.2.1 Where the yacht construction is made in large series, an alternative survey scheme to the certification may be agreed with the Society for hull to be certified by the Society, on voluntary basis.

The general requirements for the alternative survey scheme, BV Mode I, are given in NR320 Certification Scheme of Materials and Equipment, as amended.

This certification is to comply with the requirements of the present Rules and the following Society's Rules:

- for hull built in composite, plywood or HDPE materials: NR546 Composite Ships
- for hull built in aluminium alloys: NR561 Aluminium Ships.

1.2.2 This alternative survey scheme comprises the following steps:

- the review of plan and calculation, survey and tests for the issuance of a Type approval certificate,
- Yard's recognition based on initial audit and periodical audits,
- certificates of conformity issued by the Yard and submitted to the Society for endorsement.

2 Recreational craft directive (for information)

2.1 General

2.1.1 All yachts put on the European Community (EC) market and in a given hull length range L_h between 2,5 m and 24 m, are requested to be certified by a Notified body according to the Recreational Craft Directive 2013/53/EU as amended.

Exception is made for charter yachts engaged in trade that do not fall within the scope of the Recreational Craft Directive.

The present Rules Note does not cover this type of certification.

Note 1: L_h is the length according to Recreational Craft Directive EN ISO 8666:2020 as defined in Ch 1, Sec 1, [3.2.2].

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RULES FOR THE CLASSIFICATION AND THE CERTIFICATION OF YACHTS

Part B
Hull and Stability

Part B
Hull and Stability

CHAPTER 1
GENERAL

Section 1 Application and Flow Chart

1 General principles

1.1 General

1.1.1 Design life

The design life is the period during which the ship is assumed to be exposed to operating conditions.

1.1.2 Strength assessment

Strength assessments refer to the assessments aiming at covering strength checks in seagoing, harbour and flooded conditions.

1.1.3 Wave environment

Unless otherwise specified, the rule requirements are based on north Atlantic wave environment for the strength assessments.

1.1.4 Probability levels for strength assessments in sea-going conditions

The strength assessment in sea-going conditions are based on loads corresponding to the probability level of 10^{-5} over 25 years design life.

1.1.5 Design temperatures

The structural assessment of hull strength members is assumed to be valid for the following design temperatures:

- lowest mean daily average temperature in air: •10°C
- lowest mean daily average temperature in seawater: 0°C.

Ships intended to operate in areas with lower mean daily average temperature, e.g. regular service during winter seasons to Arctic or Antarctic waters, are subject to specific requirements.

In the present requirement, the following definitions apply:

- daily average: Average during one day and one night
- mean: Statistical mean over an observation period (at least 20 years)
- lowest: The lowest value during one year.

For seasonally restricted service, the lowest value within the period of operation applies.

2 General requirements

2.1 General structural requirements

2.1.1 The present Part B of the Rules contains the requirements for the determination of the minimum hull scantlings and for the intact and damage stability, applicable to all types of yachts as specified in Pt A, Ch 1, Sec 1, [1.1].

2.1.2 Yachts with novel features or unusual hull design are to be individually considered by the Society on the basis of the principles and criteria adopted in the present rules.

2.1.3 The strength of yachts constructed and maintained according to the Rules is based on the assigned intact yacht deepest full load waterline.

2.1.4 In the present Rules, the hull loadings and ship motions are estimated considering the hull shape as defined in Ch 1, Sec 2, [2.11].

2.1.5 Where scantlings are obtained from direct calculation procedures which are different from those specified in the present Rules, adequate supporting documentation is to be submitted to the Society as detailed in Ch 1, Sec 3.

2.2 Materials

2.2.1 General

The different materials considered in the present Rules are:

- steel (ordinary or high tensile)
- aluminium alloys
- composites
- wood (strip planking or plywood).
- High Density Polyethylene (HDPE).

Yachts built with different hull materials (traditional wooden construction for example) are to be specifically considered on a case by case basis.

Note 1: 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 (See Pt A, Ch 1, Sec 1, [2].

2.3 Rounding off of scantlings

2.3.1 Plate thicknesses on metallic hulls

The rounding off of plate thicknesses on metallic hulls is to be obtained from the following procedure:

a) the thickness is calculated in accordance with the rule requirements

b) the rounded thickness is taken equal to the value rounded off to the nearest half-millimetre.

2.3.2 Stiffener section moduli on metallic hulls

Stiffener section moduli as calculated in accordance with the rule requirements are to be rounded off to the nearest standard value. However, no reduction may exceed 3%.

2.4 Limits of application to equipment connections

2.4.1 The fixed parts of equipments (such as lifting appliances, crane pedestals, masts...) and their connections to the yacht's structure are considered as an integral part of the hull and are covered by the present Rules.

The fixed parts considered as an integral part of the hull are the structures permanently connected by welding or by laminating for hull in composite materials to the yacht's hull excluding any dismountable parts.

3 Rule application

3.1 General principles

3.1.1 The various Chapters and Sections of the present Part B deal with the main naval architecture of the yachts design (general arrangement, stability, hull scantling and hull outfitting) of yachts according to Tab 1.

Attention of designers is drawn on fact that some naval architecture choice, that may be decided early in the design process, are directly influencing the design options for systems fitted on board (for propulsion, piping and associated functions, power generation and control and for fire safety) covered by Part C of the present Rules, or some other statutory matters.

The most important inter linked requirement induced by the basic naval architecture options are given in Tab 2.

Table 1 : Applicable requirements for the general arrangement, stability, hull scantling and hull outfittings scantling

Items	Applicable Chapters and Sections
General arrangement (watertight bulkheads, openings in hull)	Part B, Chapter 2
Stability (intact, damage)	Part B, Chapter 3
Design loads	Part B, Chapter 4
Permissible stresses	Part B, Ch 5, Sec 3 for steel and aluminium Part B, Ch 6, Sec 3 for composite, plywood and HDPE
Steel and aluminium hull scantlings	Part B, Chapter 5
Composite, plywood and HDPE hull scantlings	Part B, Chapter 6 (see also NR546)
Steel and aluminium material	Part B, Chapter 5 and NR561 Hull in aluminium alloys
Composite, plywood and HDPE materials	NR546 Hull in composite materials
Equipment in anchors and chain cables	Part B, Ch 7, Sec 1
Rudder stock and rudder blade	Part B, Ch 7, Sec 2
Windows and sidescuttles	Part B, Ch 7, Sec 3
Shaft brackets	Part B, Ch 7, Sec 4
Independent tanks	Part B, Ch 7, Sec 5
Standing rigging and chain plates	Part B, Ch 7, Sec 6
Solid keel for sailing yachts	Part B, Ch 7, Sec 7
Other structures (helicopter deck, water jet tunnel, foil supports, lifting appliances, ice reinforcement...)	Part B, Ch 5, Sec 2 for steel and aluminium structure Part B, Ch 6, Sec 2 for composite structure

Table 2 : Inter linked requirements

Naval architecture option	Inter linked systems options
Type of hull (mono - multi) Type of propulsion (motor - sail)	Power generation Emergency source
Hull material	Fire safety and piping materials
Watertight bulkheads (distribution and arrangement)	Damage stability, if relevant
Openings in hull	Loadline and damage stability, if relevant

4 Flow chart

4.1 Design review process

4.1.1 Typical chronological steps of the design review aiming at assessing the scantlings of yachts structure against the present Rules are given in Tab 3.

Table 3 : Structure design review steps

Steps	Sub-steps	Calculation	References to Part B
1/ Materials	Steel	Mechanical characteristics	Ch 5, Sec 1
		Permissible stresses (local stress and overall stresses)	Ch 5, Sec 3
	Aluminium	Mechanical characteristics in welded conditions	Ch 5, Sec 1 and NR561
		Permissible stresses (local stress and overall stresses)	Ch 5, Sec 3
	Composites	Elastic characteristics of single layers	Ch 6, Sec 1 and NR546
		Elastic characteristics of laminates	Ch 6, Sec 1 and NR546
		Safety factors	Ch 6, Sec 3
	Plywood	Mechanical characteristics	Ch 6, Sec 1 and NR546
		Permissible stresses or safety factors	Ch 6, Sec 3
	HDPE	Mechanical characteristics	Ch 6, Sec 1 and NR546
		Permissible stresses	Ch 6, Sec 3
2 / Overall global loads	Wave global loads	In hogging, sagging and digging conditions (if relevant)	Ch 4, Sec 2, [3] and Ch 4, Sec 2, [4]
	Still water bending moment		Ch 4, Sec 2, [2]
	Rig global loads (if relevant)		Ch 4, Sec 2, [5]
3/ Global strength	Hull girder and platform scantling	Global stresses	Ch 5, Sec 4 **(1)** Ch 6, Sec 4 **(2)**
		Buckling check of members contributing to global strength	Ch 5, Sec 9 **(1)** and Ch 5, Sec 10 **(1)** Ch 6, Sec 4 **(2)**
4/ Local loads	Hydrodynamic loads	Loading on bottom, side and decks	Ch 4, Sec 3 and Ch 4, Sec 4
	Slamming loads	Loading on bottom of planing hull motor yacht and monohull sailing yachts	Ch 4, Sec 3, [3]
	Impact pressure	Loading on side shells for all type of yachts and on platform bottom for catamaran	Ch 4, Sec 3, [3.1]
5/ Local structure scantlings	Platings, secondary and primary stiffeners	Scantling	Ch 5, Sec 5 **(1)** Ch 6, Sec 5 **(2)**
	Pillars	Scantling	Ch 5, Sec 8 **(1)** Ch 6, Sec 5, [6] **(2)**

(1) for steel and aluminium structure
(2) for composite, plywood and HDPE structures
(3) for steering gear, refer to Pt C, Ch 1, Sec 3

Steps	Sub-steps	Calculation	References to Part B
6/ Watertight transverse bulkheads	Arrangement		Ch 2, Sec 1
	Local loads		Ch 4, Sec 4
	Platings and stiffeners	Scantling	Ch 5, Sec 5 **(1)** Ch 6, Sec 5 **(2)**
7/ Superstructures	Local sea pressure and minimum pressure		Ch 4, Sec 4
	Platings and stiffeners	Scantling	Ch 5, Sec 5 **(1)** Ch 6, Sec 5 **(2)**
8/ Openings	Height of door sills, openings in hull, windows scantling		Ch 2, Sec 2 and Ch 7, Sec 3
9/ Additional calculations	Anchors and chains	Equipment number	Ch 7, Sec 1
	Rudder, rudder stock, steering gear **(3)**		Ch 7, Sec 2
	Propeller shaft brackets		Ch 7, Sec 4
	Independent tanks		Ch 7, Sec 5
	Chain plates for sailing yachts standing rigging		Ch 7, Sec 6
	Solid keel for sailing yacht		Ch 7, Sec 7

(1) for steel and aluminium structure
(2) for composite, plywood and HDPE structures
(3) for steering gear, refer to Pt C, Ch 1, Sec 3

Section 2 Symbols and Definitions

Symbols

L : Rule length, in m, defined in [2.2.1]

L_{WL} : Waterline length, in m, defined in [2.2.1]

L_{LL} : Load line length defined in [2.2.5]

L_h : Length according to EC Directive EN ISO 8666:2020

L_{HULL} : Hull length, in m, defined in [2.2.2]

B : Moulded breadth, in m, defined in [2.4]

B_{WL} : Greatest moulded breadth on waterline at draught T, in m, defined in [2.4]

D : Depth, in m, defined in [2.5]

T : Full load draught, in m, defined in [2.6]

Δ : Full load displacement, in tonnes, at draught T, in sea water (density ρ = 1,025 t/m^3).

C_B : Total block coefficient defined in [2.7.1].

C_W : Wave parameter, in m

V : Maximum speed, in knots, of the yacht

LCG : Longitudinal centre of gravity of the yacht

a_{CG} : Design vertical acceleration, in terms of g, defined in [2.13]

H_S : Significant wave height, in m, defined in [2.12].

1 Units

1.1 Units definition

1.1.1 Unless otherwise specified, the units used in the present Rules are those defined in Tab 1.

Table 1 : Units

Designation	Usual symbols	Units
Yacht's dimensions	See [2]	m
Hull girder section modulus	Z	m^3
Density	ρ	t/m^3
Concentrated loads	P	kN
Linearly distributed loads	q	kN/m
Surface distributed loads	p	kN/m^2
Thicknesses	t	mm
Span of ordinary stiffeners and primary supporting members	ℓ	m
Spacing of ordinary stiffeners and primary supporting members	s	m
Bending moment	M	kN.m
Shear force	Q	kN
Stresses	σ τ	N/mm^2
Section modulus of ordinary stiffeners and primary supporting members	w	cm^3
Section area of ordinary stiffeners and primary supporting members	A	cm^2
Accelerations	a_i	In terms of g
Acceleration due to gravity	g	9,81 m/sec^2

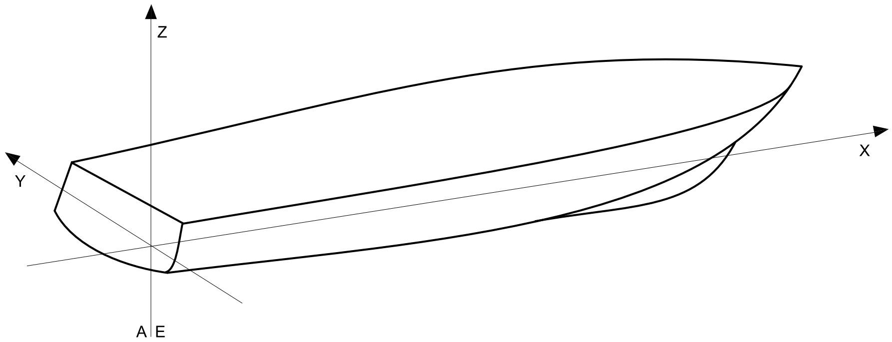
1.2 Reference co-ordinate system

1.2.1 The yacht's geometry, motions, accelerations and loads are defined with respect to the following right-hand co-ordinate system defined in Fig 1.

- Origin: at the intersection of the longitudinal plane of symmetry of yacht, the aft end of L and the moulded baseline
- X axis: longitudinal axis, positive forwards
- Y axis: transverse axis, positive towards portside
- Z axis: Vertical axis, positive upwards.

1.2.2 Positive rotations are oriented in anti-clockwise direction about the X, Y and Z axes.

Figure 1 : Reference co-ordinate system



2 Definitions

2.1 Moulded base line

2.1.1 The moulded base line is the horizontal reference line tangent to the upper face of bottom plating at midship.

In the case of yacht with a solid bar keel, the moulded base line is to be taken at the intersection between the upper face of the bottom plating and the solid bar keel at the middle of length L.

2.2 Lengths

2.2.1 Rule length L

The rule length L is the distance, in m, measured on the summer load waterline, from the fore side of the stem to the after side of the rudder post, or to the centre of the rudder stock where there is no rudder post.

L is to be taken not less than 96%, and need not exceed 97%, of the extreme length on the summer load waterline.

2.2.2 Hull length L_{HULL}

The hull length L_{HULL} is equal to the distance, in m, measured from the fore end of the hull to the aft end of the hull.

2.2.3 Waterline length L_{WL}

The waterline length L_{WL} is equal to the distance, in m, measured from the intersection between the waterline at full load displacement and the fore end of the hull to the aft end of the hull.

2.2.4 Length L_W

The length L_w, in m, is to be taken equal to:

$L_w = 0,5\ (L_{WL} + L_{HULL})$

2.2.5 Load line length

The Load Line length L_{LL} is the length according to the International Convention on Load Line as defined in Pt A, Ch 1, Sec 1, [3.2.2].

2.3 Ends of rule length and midship

2.3.1 Fore end

The fore end (FE) of the rule length (see Fig 2) is the perpendicular to the full load waterline at the forward side of the stem.

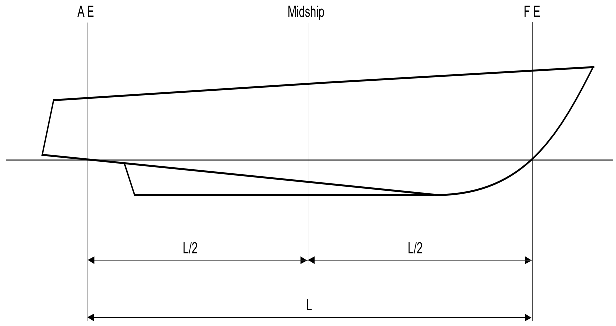
2.3.2 Aft end

The aft end (AE) of the rule length (see Fig 2), is the perpendicular to the full load waterline at a distance L_{WL} aft of the fore end.

2.3.3 Midship

The midship is the perpendicular to the waterline at a distance 0,5L aft of the fore end (see Fig 2).

Figure 2 : Ends and midship



2.4 Breadths

2.4.1 Moulded breadth B

The moulded breadth B, in m, is the greatest moulded breadth of the hull below the weather deck.

2.4.2 Waterline breath B_{WL}

The breadth B_{WL}, in m, is the greatest moulded breadth of the hull at full load waterline. For catamarans, B_{WL} is the breadth of each hull.

2.4.3 Breath B_E between multihull float

The breadth B_E between the floats of a multihull is the distance, in m, measured between the longitudinal planes of symmetry of the floats. As a rule, the longitudinal plane of symmetry of a float is located at 0,5 B_{WL}.

2.5 Depth

2.5.1 The depth D, in m, is the distance measured vertically on the midship transverse section, from the moulded base line to the top of the deck beam at side on the uppermost continuous deck.

2.6 Draught

2.6.1 The full load draught T, in m, is the distance, measured vertically on a transverse section located at $L_{WL}/2$, from the moulded base line to the full load waterline.

In the case of yachts with a solid bar keel, the moulded base line is to be taken as defined in [2.1].

2.7 Total block coefficient C_B

2.7.1 The total block coefficient C_B is to be taken equal to:

- for monohull:

$$C_B = \frac{\Delta}{1,025 L_{WL} B_{WL} T}$$

- for catamaran:

$$C_B = \frac{\Delta}{1,025 L_{WL} 2 B_{WL} T}$$

where:

Δ	:	Moulded displacement, in tonnes, at draught T, in sea water (density ρ = 1,025 t/m^2)
L_{WL}	:	Waterline length, in m, as defined in [2.2.3]
B_{WL}	:	Breadths, in m, measured amidships, as defined in [2.4.2]
T	:	Moulded draught, as defined in [2.6.1].

2.8 Chine

2.8.1 Chine

For hulls without a clearly identified chine, the chine is the hull point where the tangent to the hull is inclined by 50° compared to the horizontal.

2.9 Lightweight

2.9.1 The lightweight, in t, is the displacement without fuel, lubricating oil, ballast water, fresh water and feed water, consumable stores, passengers and crew with their effects, tenders, jet-skis... but including liquids in piping.

2.10 Deadweight

2.10.1 The deadweight, in t, is the difference between the full load displacement, at the summer draught in sea water of density ρ = 1,025 t/m^3, and the lightweight.

2.11 Hull shape

2.11.1 The two following hull shapes are considered in the present Rules:
- displacement hull: hull designed to be mainly supported by the pressure of water displaced by the hull
- planing hull: hull designed to use hydrodynamic lift to rise up and glide on the surface of the water when the hull speed exceeds a critical value. Under this critical speed value, the hull behaviour is to be considered as a displacement hull.

The Designer must specify to the Society if the hull is a planing hull and if bottom slamming impacts are expected to occur.

In this case, the design vertical acceleration at L_{CG}, to be defined by the Designer, is to correspond to the highest accelerations obtained from a relationship between the actual ship speed and the sea state conditions expected by the Designer.

Planing hulls for which $V \geq 10\ L_{WL}^{0,5}$ are individually considered by the Society, where:

V : Speed of the ship, in knots

L_{WL} : Waterline length, as defined in [2.2.3].

Note 1: As a guidance, a ship may be considered as able to sail in planing hull mode when: $V \geq 7{,}16\ \Delta^{1/6}$, with:

Δ : Moulded displacement, in tonnes, at draught T, in sea water (density ρ = 1,025 t/m^2)

2.12 Wave characteristics

2.12.1 The wave height H_S, in m, is the significant wave height ($H_{1/3}$) of the considered sea-state.

2.12.2 The wave length L_W, in m, is the distance between two consecutive crests of the wave.

2.13 Design vertical acceleration

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

2.14 Freeboard deck$^{(m)}$

2.14.1 The freeboard deck$^{(m)}$ is defined in Ch 2, Sec 2, [2.2.1].

2.15 Bulkhead deck

2.15.1 The bulkhead deck is defined in Ch 2, Sec 1, [1.2.1].

2.16 Multihull platform

2.16.1 A multihull platform is a strength structure connecting the hulls by primary transverse cross structure elements. These transverse elements may be cross beams or cross bulkheads.

The part of the platform directly exposed to sea effect is designed as platform bottom.

The upper part of the platform together with the upper decks are defined as platform deck.

Section 3 Documentation to be Submitted

1 Documentation to be submitted

1.1 Yachts surveyed by the Society during the construction

1.1.1 Plans and documents to be submitted for approval

The plans and documents to be submitted to the Society for approval are listed in Tab 1.

These plans and documents are to be supplemented by further documentation which depends on the service notation and, possibly, the additional class notation (see Pt A, Ch 1, Sec 2) assigned to the yacht.

For yachts built in composite, plywood or HDPE materials, additional drawings and informations as listed in NR546, Hull in Composite Materials are to be submitted.

For yachts built in aluminium alloys, additional informations as listed in NR561, Aluminium Ships are to be submitted.

Structural plans are to specify the materials used, including their manufacturing processes, welded procedures and heat treatments and are to show details of connections of the various parts of the hull.

1.1.2 Plans and documents to be submitted for information

In addition to [1.1.1], the following plans and documents are to be submitted to the Society for information:

- general arrangement
- lines plan
- hydrostatic curves
- lightweight distribution.

When direct calculation analyses are carried out by the Designer according to the rule requirements, the details of these calculations are to be submitted to the Society.

1.2 Yachts for which the Society acts on behalf of the relevant Administration

1.2.1 Plans and documents to be submitted for approval

The plans and documents required by the National Regulations requirements are to be submitted to the Society for approval, in addition to those in [1.1].

The list of drawings and documents to be submitted is to be finalized at the beginning of the design review process, depending on Administration requirements.

1.3 Yachts certified under alternative survey scheme for production in large series

1.3.1 The plans and documents to be submitted to the Society for approval within the scope of alternative survey scheme for production in large series according to Pt A, Ch 1, Sec 3 are listed in NR320 Rules for Approval & Inspection at Works, NR546 Hull in Composite Materials and NR561 Aluminium Ships.

Table 1 : Plans and documents to be submitted for approval of all yachts

Plans or documents	Containing also information on
Midship section and/or transverse sections Shell expansion Decks and profiles Double bottom Pillar arrangements Framing plan	Class characteristics Main dimensions Minimum ballast draught Frame spacing Maximum ahead service speed, design vertical acceleration for planing hull Design loads on decks Location and height of air vent outlets in various compartments Corrosion protection Openings in decks and shells and their relevant compensations Details of structural reinforcements and/or discontinuities Bilge keel with details of connection to hull structures
Watertight subdivision bulkheads Inner watertight doors	Openings and their closing appliances, if any

Plans or documents	Containing also information on
Fore part structure Aft part structure	
Transverse thruster, if any, general arrangement, tunnel structure, connections of thruster with tunnel and hull structures	
Foundations of propulsion machinery, generators...	Type, power and r.p.m. of propulsion machinery Mass and centre of gravity of machinery, generators...
Superstructures and deckhouses	
Transom doors, if any, side doors and other openings in the side shell Plan of outer doors Deck covers, if any	Closing appliances Design loads on deck covers
Windows and side scuttles, arrangements and details	Scantling and mechanical characteristics of glazing
Scuppers and sanitary discharges	
Bulwarks and freeing ports	Arrangement and dimensions of bulwarks and freeing ports on the freeboard deck(m) and superstructure deck
Helicopter decks, if any	General arrangement Main structure Characteristics of helicopters: maximum mass, distance between axles of wheels or skids, print area of wheels or skids, rotor diameter
Rudder and rudder horn **(1)**	Maximum ahead service speed (motor propulsion and wind propulsion for sailing yachts)
Sternframe or sternpost, sterntube Propeller shaft boss and brackets **(1)**	
Sea chests, stabilizer recesses, etc.	
Hawse pipes	
Plan of manholes	
Plan of access to and escape from spaces	
Plan of ventilation	Use of spaces
Plan of independent liquid tank and/or capacities	Location and height of air vent outlets of the various compartments
Plan of watertight doors and scheme of relevant manoeuvring devices	Manoeuvring devices Electrical diagrams of power control and position indication circuits
Freeboard calculations, if applicable	
Stability documentation	See Ch 3, Sec 1, [2.1]
Calculations relevant to intact stability and damage stability	See Ch 3, Sec 2 and Ch 3, Sec 3
Equipment number calculation	Geometrical elements for calculation List of equipment Construction and breaking load of steel wires Material, construction, breaking load and relevant elongation of synthetic ropes
Solid keel	Weight and centre of gravity Details of the connection between the hull and the solid keel Mechanical characteristics of the materials used
For sailing yachts: Chainplates Pillar under mast	Maximum forces applied by the rigging and the mast to the hull structure for all design conditions on which the wind propulsion system is based Forces and reinforcements in way of winches Mechanical characteristics of the materials used for chainplates Details of connections with the hull structure
(1) Where other steering or propulsion systems are adopted (e.g. steering nozzles or azimuth propulsion systems), the plans showing the relevant arrangement and structural scantlings are to be submitted.	

Part B
Hull and Stability

CHAPTER 2
GENERAL ARRANGEMENT DESIGN

Section 1 Subdivision Arrangement

1 General

1.1 Application

1.1.1 Watertight compartment arrangement

As a rule, yacht of more than 15 m are to have the following watertight compartment located below the freeboard deck$^{(m)}$:

- fore peak
- machinery space
- stern tube
- fin shaft stabilizer
- compartment having a direct access opening on the hull.

Additional watertight compartment may be required for yachts having to comply with damage stability criteria, according to requirements of Part B, Chapter 3.

1.2 Definition

1.2.1 Bulkhead deck

A bulkhead deck may be the watertight deck:

- to which the main bulkheads and the ship's shell are provided watertight, and
- whose the deck line at any point of the yacht length should not be submerged at the equilibrium in any stage of flooding for damage cases defined in Ch 3, Sec 3.

A bulkhead deck may be a stepped deck.

Where no bulkhead deck is provided, the freeboard deck$^{(m)}$ Ch 2, Sec 2, [2.2.1] is to be considered as a bulkhead deck.

1.2.2 Freeboard deck$^{(m)}$

This deck noted freeboard deck$^{(m)}$ in the present Rules is to be considered as the deck exposed to greenseas, and granting the necessary weathertightness of the hull to prevent any water ingress.

1.2.3 Watertight

Watertight means having scantlings and arrangements capable of preventing the passage of water in any direction under the head of water likely to occur in intact and damage conditions.

1.2.4 Vertical extension of watertight bulkheads

a) Yacht having to comply with damage stability:

   For yacht having to comply with damage stability, the watertight bulkheads requested in the present Section are to ensure that sufficient buoyancy is maintained to meet the damage stability and are to be fitted, as a rule, up to the bulkhead deck defined in [1.2.1].

   These watertight bulkheads are to be capable of supporting the flooding pressure defined in Ch 4, Sec 4, [4].

b) Other yacht:

   Except where otherwise required, the watertight bulkhead may be stopped to an intermediate watertight deck located below the bulkhead deck.

2 Fore peak compartment

2.1 General

2.1.1 The fore peak compartment is to be bounded by a watertight collision bulkhead up to the bulkhead deck. This bulkhead is to be located at a distance from the forward perpendicular (FE) of not less than 0,05 L_{WL} and, except as may be permitted by the Society, not more than:

- 0,05 L_{WL} +3 m, or
- 5,5 m,

whichever is the greater, where:

(FE) : Fore end as defined in Ch 1, Sec 2, [2.3.1]

L_{WL} : Yacht waterline length, in m, as defined in Ch 1, Sec 2, [2.2.3]

2.1.2 Where a bulbous bow below the waterline extends forward of the forward perpendicular, the distances defined in [2.1.1] are to be measured from the point either:

- at the mid-length of such extension, or
- at a distance 1,5 per cent of the length L_{WL} of the yacht forward of the forward perpendicular,

whichever gives the smallest measurement.

2.1.3 At Interested Party request and subject to the agreement of the flag Administration, the Society may, on a case by case basis, accept a distance from the collision bulkhead to the forward perpendicular (FE):.

- greater than the maximum specified in [2.1.1], provided that the subdivision and stability calculations show that, when the yacht is in upright condition, flooding of the space forward of the collision bulkhead will not result in any part of the bulkhead deck becoming submerged, or in any unacceptable loss of stability
- lower than the minimum specified in [2.1.1] for short range motor yacht and motor yacht not engaged in trade having a pronounced rake of stem.

2.1.4 The collision bulkhead may have steps or recesses provided they are within the limits prescribed in [2.1.1] and [2.1.3].

Note 1: Other arrangement of recess location may be examined on a case by case basis.

2.1.5 As a rule, no door, manhole, ventilation duct or any other opening is to be fitted in the collision bulkhead.

However, when an access through the collision bulkhead is deemed necessary for the proper working of the yacht, a manhole may be accepted provided the following requirements are met:

- agreement of the Interested Party and flag Administration on the proposed arrangement
- the manhole is fitted, as far as practicable, in the upper part of the collision bulkhead
- a permanent watertight close device, having the same resistance as surrounding bulkhead and bolted to the collision bulkhead, is provided
- a permanent sign, fixed on the collision bulkhead and indicating that the manhole is to be permanently closed, is to be displayed, and
- an audible and/or visual alarm is automatically actuated when the manhole is open.

2.1.6 On a case by case basis, it may be accepted that pipes cross the collision bulkhead, provided the crossing be fitted in upper part of the collision bulkhead and made watertight.

3 Machinery compartment

3.1 General

3.1.1 Bulkheads are to be fitted separating the machinery spaces and the sterntube from passenger and crew spaces.

These bulkheads are to be made watertight up to the bulkhead deck. They may, however, be stopped to an intermediate watertight deck below the bulkhead deck, provided the degree of safety of the ship as regards subdivision and damage stability, when requested, is not thereby diminished.

4 Stern tubes and fin shaft stabilizer

4.1 General arrangement

4.1.1 Stern tube

When the sterntube is not located in a watertight compartment, sterntubes are to be enclosed in a watertight space of moderate volume. Other measures to minimize the danger of water penetrating into the yacht in case of damage to sterntube arrangements may be taken at the discretion of the Society.

4.1.2 Fin shaft stabilizer

When a fin stabilizer is provided, attention is to be paid to the watertightness of the hull in way of the fin shaft crossing. As a general rule, this type of equipment is to be located in a watertight compartment, or a watertight space of moderate volume.

5 Compartment with access on the hull

5.1 General

5.1.1 A compartment located below the freeboard deck$^{(m)}$ and having a direct access opening on the hull is to be bounded by watertight bulkheads up to the bulkhead deck or to an intermediate watertight deck to separate it from the other adjacent compartments located below the freeboard deck$^{(m)}$.

The attention is drawn to the requirements of National or International Rules which may request specific arrangements for such a compartment and its access.

6 Openings in watertight bulkheads and decks

6.1 General

6.1.1 The number of openings in watertight subdivision bulkheads and decks is to be kept to a minimum compatible with the design and the proper working of the yacht. Where penetration of watertight bulkheads and decks are necessary for access, piping, ventilation, electrical cables, etc., arrangements are to be made to maintain the watertight integrity.

6.1.2 Lead or other heat sensitive materials may not be used in systems which penetrate watertight subdivision bulkheads and decks, where deterioration of such systems in the event of fire would impair the watertight integrity.

6.1.3 Valves not forming part of a piping system are not permitted in watertight subdivision bulkheads and decks.

6.2 Watertight doors

6.2.1 General arrangement

The doors fitted in watertight bulkheads are to be watertight with the same strength as surrounding bulkheads.

The hand opening and hand closing devices of the door by hand are to be operable from both sides of the door.

6.2.2 Class requirements

Indicators are to be provided at the control position showing whether the doors are open or closed.

6.2.3 Other requirements

Flag Administrations or International Rules may request that:

- watertight doors used while at sea be of sliding watertight type capable of being remotely closed from the bridge and be also operable locally from each side of the bulkhead
- an audible alarm be provided at the door closure
- the power, control and indicators be operable in the event of main power failure
- particular attention be paid to minimize the effect of control system failure
- each power-operated sliding watertight door be provided with an individual hand-operated mechanism.

Section 2 Integrity and Opening in Hull

1 General

1.1 General

1.1.1 The requirements of the present Section are applicable to yachts and charter-yachts in the scope of the Classification only.

To that purpose, they only deal with the different protection index to be provided for the openings in decks and superstructures exposed to sea in a view to prevent any flooding of the floating hull under sea effect of such decks and superstructures.

1.1.2 The attention of Interested Party is drawn on the fact that compliance to the requirements of the present Section is not necessarily sufficient at all to satisfy flag Administration requirements (issue of a load line certificate for example).

1.1.3 The flag Administration may request, for yacht greater than 24 m length load line, application of National Rules and/or International Regulations. In such a case, it is the Interested Party responsibility to comply with the therein Rules and Regulations which can be different from the requirements of the present Section.

1.1.4 When agreed by the flag Administration, the Society may act on behalf of the flag Administration in the scope of National Rules and/or International Regulations.

In such case, the requirements of the present section will be superseded by the National or International Rules recognized by the flag Administration.

Note 1: In the scope of the limits of such authorization, the Society only notices the arrangements which are not in accordance with the requirements of the National and/or International Rules. It is to the flag Administration responsibility to request or not new arrangement within the scope of the National and/or International Rules.

2 Interpretation principle

2.1 General

2.1.1 Main definition

The main definitions of the present section are the one of the International Convention on Load lines, 1966, as amended.

2.1.2 Interpretation

The only purpose of the interpretations given with each definition in the present Section (and which may differ from the International Load Line Convention) is to specify the list of requirements applicable for openings protection in the scope of Classification only.

2.2 Definitions and interpretations

2.2.1 Freeboard deck

a) Freeboard deck:

The freeboard deck is normally the uppermost complete deck exposed to weather and sea, which has permanent means of closing all openings in the weather part thereof, and below which all openings in the sides of the ship are fitted with permanent means of watertight closing.

b) Freeboard deck$^{(m)}$:

Interpretation:

This deck noted freeboard deck$^{(m)}$ in the present Rules is to be considered as the deck exposed to greenseas, and granting the necessary weathertightness of the hull to prevent any water ingress.

2.2.2 Bulkhead deck

As defined in Ch 2, Sec 1, [1.2.1].

2.2.3 Superstructure

a) A superstructure is a decked structure on the freeboard deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4 per cent of the breadth (B).

b) An enclosed superstructure is a superstructure with:

1) enclosing bulkheads of efficient construction
2) access openings, if any, in these bulkheads fitted with doors complying with the requirements of Regulation 12 of the International Convention on Load Lines 1966 as amended, dealing with the doors arrangement
3) all other openings in sides or ends of the superstructure fitted with efficient weathertight means of closing.

Interpretation:

A superstructure, noted superstructure(m) in the present Rules, is to be considered as a decked structure on the freeboard deck(m) and complying with the requirements of Ch 5, Sec 2, [8] and Ch 6, Sec 2, [6] even if it is inboard of the shell plating more than 4% of the breadth. A superstructure(m) may be:

- enclosed(m): if all the openings in the exposed surrounding sides and decks are made weathertight as indicated in [2.2.5] of the present article
- open(m): if the openings in the exposed surrounding sides and decks are not all made weathertight.

Note 1: The part of the freeboard deck(m) sheltered by an enclosed(m) superstructure(m) is not to be considered as a deck exposed to greenseas.

2.2.4 Deckhouse

A deckouse is a decked structure other than a superstructure, located on the freeboard deck(m) or above.

2.2.5 Weathertightness

Weathertight means that in any sea conditions, water will not penetrate into the ships.

The weathertight closing devices (door, hatch cover,....) are to be of strong construction and with strength criteria similar to the adjacent ship's structure.

2.2.6 Green sea exposure location

The locations are defined as follows:

- fore area: area extending on the forward 1/4 of the ship's rule length from the forward perpendicular
- aft area: area extending abaft the fore area
- fore deck: exposed part of the freeboard deck(m) and side walls or front wall of the first tier of superstructure(m) on the freeboard deck(m), located in the fore area
- 1st tier of fore area: exposed part of the first deck above the freeboard deck(m) and side walls or front wall of superstructure located on this deck, located in the fore area.

3 General arrangement design, height of sills and coamings

3.1 General

3.1.1 The scantlings of the doors, hatchways, superstructure windows and side scuttles giving access below the freeboard deck(m) are to be determined with the values of sea pressure given in Ch 4, Sec 4, and with due consideration given to the material used for the construction.

Weathertighness is to be demonstrated after fitting on board by means of hose tests or equivalent test.

3.2 Doorways and companionways

3.2.1 All the openings exposed to greenseas and giving direct or indirect access below the freeboard deck(m) are to be fitted with closing devices and are to be weathertight.

3.2.2 The closing means are to be permanently ready for use, fitted with locking devices and with opening outward.

3.2.3 For classification purpose, the openings mentioned in [3.2.1], are to be fitted with sill or coamings having the following minimum height:

- fore deck: 600 mm
- 1st tier of fore area: 150 mm
- aft area:
  - 300 mm for doors, hatchways and companion ways directly exposed to green sea effects
  - 150 mm for doors in side walls of superstructure (see Note 1)
  - 100 mm for protected doors, hatchways and companion ways in aft wall of superstructure (see Note 1).

Note 1: Flag Administrations may request height of sill or coaming higher than 150 mm or 100 mm to issue an International or National Load Line Certificate.

- direct access to machinery space: 600 mm.

  This height may be reduced to 380 mm where this access is located in the aft area and is not directly exposed to green seas effect.

3.2.4 Doors not used during navigation can be provided without sills. In such case, permanent warnings are to be fitted close to the concerned doors, specifying that the door under consideration is not to be used during navigation.

For engine room and steering gear compartments, such arrangement is only acceptable if a second access to these compartments is provided.

3.2.5 Removable sills

Except for the fore deck, a part of the required sill of the openings used during navigation may be made of removable part, provided:

a) the removable sill is permanently stored close to the opening, and

b) the weathertightness of the complete sill is satisfactorily demonstrated by a hose test.

3.2.6 For yachts having the navigation notation **sheltered area** or **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, and for yachts under 300 UMS not engaged in trade, the height of sills and coamings as required in [3.2.3] may be reduced by half, excepted for access to engine room where the height of sills may be reduced to respectively 450 mm (instead of 600 mm) and 200 mm (instead of 380 mm) in relation to values given in [3.2.3].

In this case, fitting of removable sills according to [3.2.5] cannot be simultaneously accepted.

3.2.7 At Interested Party request and subject to the agreement of the flag Administration, other arrangements than [3.2.3] to [3.2.6] may be considered on a case by case basis for yachts not engaged in trade.

3.3 Hatchways

3.3.1 Deck hatchway exposed to greenseas and giving direct or indirect access below the freeboard deck$^{(m)}$ are to be as small as possible, located as near as practicable to the centreline, fitted with coamings as defined in [3.2.3] and with, as a general rule, hinges located on the forward side.

Deck hatchway not used during navigation can be provided without coaming. In such case, permanent warnings are to be fitted close to the concerned deck hatchway specifying that the deck hatchway under consideration is not to be used during navigation.

As a rule, when the deck hatchway is the only access leading to the steering gear or machinery space, the arrangement and the height of the coaming are to be as defined in [3.2.1], [3.2.2] and [3.2.3].

3.3.2 At Interested Party request and subject to the agreement of the flag Administration, other arrangements than [3.3.1] may be considered on a case by case basis for yachts not engaged in trade.

3.4 Ventilation openings

3.4.1 Spaces located below the freeboard deck$^{(m)}$

The ventilation openings serving spaces located below the freeboard deck$^{(m)}$ are to be protected from direct greenseas effect and are to be fitted, as a rule, with a sill of height equal to:

- 900 mm where located in fore area
- 760 mm where located in aft area.

The ventilation openings must be fitted with water trap system.

Smaller sill heights may be accepted provided:

- ventilation openings is located in a protected area not directly exposed to green seas effect
- ventilation openings are fitted with efficiency systems limiting direct water ingress (The efficiency of the system is to be tested by hose).

3.4.2 Machinery space

As a rule, the sills height of ventilation openings serving the machinery space are the same than those defined in [3.4.1].

At the Interested Party request and subject to the agreement of the flag Administration, for yacht not engaged in trade and for charter yacht of less than 300 GT having the navigation notation **navigation limited to 60 nautical miles**, other arrangement with efficiency safety devices limiting direct water ingress tested by hose may be considered on a case by case basis by the Society.

3.4.3 For yachts having the navigation notation **sheltered area** or **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, and for yachts under 300 UMS not engaged in trade, the height of the sills as defined in [3.4.1] and [3.4.2] may be reduced by half.

3.5 Side scuttles

3.5.1 Side scuttle arrangement

As a general rule, a side scuttle is an opening with an area not exceeding 0,16 m^2.

The lower edge of the side scuttle fitted in the hull is to be at least 500 mm above the waterline.

3.5.2 Non-opening sidescuttle type are to be provided:

- where they become immersed by any intermediate stage of flooding or the final equilibrium waterplane in any required damage case for ships subject to damage stability regulations
- in the first tier of superstructures and deckhouses considered as being buoyant in the stability calculations.

Note 1: Permanently attached or portable deadlight arrangement are not covered within the scope of classification and are to be in accordance with the flag Authorities.

3.6 Windows

3.6.1 As a general rule, a window is an opening with an area exceeding 0,16 m^2 and may not be fitted on the hull below the freeboard deck(m).

Opening type windows may not be fitted:

- where they become immersed by any intermediate stage of flooding or the final equilibrium waterplane in any required damage case for ships subject to damage stability regulations
- in the first tier deckhouses considered as being buoyant in the stability calculations.

Note 1: Proposal to fit windows in the hull below the freeboard deck(m) may be examined on a case by case basis by the Society taking into account the location and the strength of the window, the subdivision arrangement of the hull and the deadlight arrangement provided to securing in case of a breakage of the window.

These arrangements are to be submitted to the flag Authorities.

3.7 Openings in the hull

3.7.1 External hull openings leading to compartments below the freeboard desk(m) assumed intact in the damage analysis which are below the final damage waterline are to be fitted with doors having the same watertightness and structural integrity as the surrounding shell structure.

As a rule, the lower edge of the external hull door is to be at least 230 mm above the full load waterline. However, attention is drawn to the that the Flag Administration may request a higher value.

As a rule, the compartment accessed via the external hull door is to be bounded by watertight bulkheads as defined in Ch 2, Sec 1, [5].

4 Freeing ports

4.1 Freeing ports

4.1.1 General

Where bulwarks on the weather freeboard deck(m) or superstructure(m) decks form wells, freeing ports area are to be provided.

The minimum section area of the freeing ports, in scope of classification, is determined according to [4.1.2].

Note 1: Flag Authority may request other requirements to issue an International or National Load Line certificate.

4.1.2 Minimal section

As a rule, the minimal section area A of freeing ports, in m^2, on each side of the bulwark is not to be less than:

- Value given in Tab 1 for the freeboard deck(m) in area where there is no superstructure or deckhouse on the deck
- value equal to one-half to the value given in Tab 1 for the superstructure(m) deck in area where there is no deckhouse on the superstructure deck
- value given as a percentage of the lateral surface of the corresponding bulwark according to Tab 2 where there is superstructure or deckhouse on the exposed deck considered.

4.1.3 Location

The lower edge of the freeing ports is to be as close to deck as possible.

Freeing ports are to be located in the areas of the well where the sea water may accumulate due to yacht motions at sea.

Table 1 : Freeing ports for deck without decked construction

Area A of freeing ports, in m^2	
$\ell_B \leq 20$	$\ell_B > 20$
$0{,}7 + 0{,}035\ \ell_B + A_C$	$0{,}07\ \ell_B + A_C$

Note 1:

ℓ_B : Length, in m, of bulwark in the well, to be taken not greater than 0,7 L_{HULL}

A_C : Area, in m^2, to be taken, with its sign, equal to:

$$A_C = \frac{\ell_B}{25}(h_B - 1,2) \text{ for } h_B > 1,2$$

$$A_C = 0 \qquad \text{for } 0,9 \leq h_B \leq 1,2$$

$$A_C = \frac{\ell_B}{25}(h_B - 0,9) \text{ for } h_B < 0,9$$

h_B : Mean height, in m, of the bulwark in a well of length ℓ_B

Table 2 : Freeing ports for deckwith decked construction

Relative breadth of the superstructure or the decked construction, compared to the breadth of the deck	Minimum area of freeing ports on each side compared to the lateral area of the lateral bulwark
40%	10%
50%	8,6%
60%	7,1%
70%	5%
80% and more	4,3%

4.1.4 Protection

All such openings in the bulwarks are to be protected by rails or bars spaced approximately 230mm apart. If shutters are fitted to freeing ports, ample clearance is to be provided to prevent jamming. Hinges are to have pins or bearings of non-corrodible material.

Part B
Hull and Stability

CHAPTER 3
STABILITY

Section 1 General Requirements

1 General

1.1 Application

1.1.1 General

All yachts carrying less than 36 passengers may be assigned class only after it has been demonstrated that their stability is adequate. Adequate stability means compliance with standards laid down with the requirements specified in the relevant chapters taking into account the yacht's size and the navigation notation. See Tab 1.

All yachts carrying 36 or more passengers are considered as passenger ships.

Table 1 : Application

Navigation notation	Length	
	$L_{LL} \leq 24$ m	$L_{LL} > 24$ m
sheltered area	Ch 3, Sec 2	Ch 3, Sec 2
coastal area	Ch 3, Sec 2	Ch 3, Sec 2
navigation limited to 60 nautical miles	Ch 3, Sec 2	Ch 3, Sec 2
unrestricted navigation	Ch 3, Sec 2	Ch 3, Sec 2 and Ch 3, Sec 3 **(1)**
(1) Are exempted from damage stability for yacht under 300 UMS not engaged in trade.		

1.1.2 Approval of the Administration

Evidence of approval by the Administration concerned may be accepted for the purpose of Classification, if demonstrated that their requirements are at least equal to those defined in the relevant chapter of these rules.

2 Examination procedure

2.1 Documents to be submitted

2.1.1 List of documents

For the purpose of the examination of the stability, the following documents are to be submitted:

- lines plan
- general arrangement plan. In addition for sailing yachts, a general arrangement plan showing the sails lowered on the rigging and masts
- capacity plan indicating the volume and position of the centre of gravity (coordinates X, Y, Z), of all compartments and tanks and the free surfaces
- hydrostatic tables or curves
- lightship particulars
- trim and stability booklet
- when applicable, damage stability calculations.

2.1.2 Documents for approval

The report of the inclining experiment, the trim and stability booklet and when applicable the damage stability calculations are to be submitted for approval.

2.1.3 Provisional documentation

Provisional stability documentation based on the estimated lightship particulars should be submitted for examination.

2.1.4 Final documentation

Final stability documentation based on the results of the inclining experiment or the lightweight check is to be submitted for examination.

When the difference between the estimated values of the lightship and those obtained from the inclining experiment or the lightweight check is less than:

- 2% for the displacement and
- 1% of the length between perpendiculars for the longitudinal position of the centre of gravity

and the determined vertical position of the centre of gravity is not greater than the estimated vertical position of the centre of gravity, the provisional stability documentation may be accepted as the final stability documentation.

2.2 Inclining experiment/lightweight check

2.2.1 Definitions

The following definitions are used in the present Chapter:

a) Lightship

The lightship is a yacht complete in all respects, but without consumable, stores, and crew and effects, and without any liquids on board except for machinery and piping fluids, such as lubricants and hydraulics, which are at operating levels

b) Inclining experiment

The inclining experiment is a procedure which involves moving a series of known weights, normally in the transverse direction, and then measuring the resulting change in the equilibrium heel angle of the yacht. By using this information and applying basic naval architecture principles, the yacht's vertical centre of gravity (VCG or KG) is determined

c) Lightweight check

The lightweight check is a procedure which involves auditing all items which are to be added, deducted or relocated on the yacht at the time of the inclining experiment so that the observed condition of the yacht can be adjusted to the lightship condition. The weight and longitudinal, transverse, and vertical location of each item are to be accurately determined and recorded. The lightship displacement and longitudinal centre of gravity (LCG) can be obtained using this information, as well as the static waterline of the yacht at the time of the lightweight survey as determined by measuring the freeboard or verified draughts marks of the yacht, the yacht's hydrostatic data and the sea water density.

2.2.2 General

The inclining experiment or the lightweight check is to be attended by a Surveyor of the Society. The Society may accept inclining experiment or lightweight check attended by a member of the Flag Administration.

After completion, the yacht is subject to an inclining experiment. In some particular cases as described in [2.2.4], the Society may accept a lightweight check.

2.2.3 Inclining experiment

The inclining experiment is required in the following cases:

- any new yacht, after its completion, except for the cases specified in [2.2.4]
- any yacht, if deemed necessary by the Society, where any alterations are made so as to materially affect the stability.

2.2.4 Lightweight check

The Society may allow a lightweight check to be carried out in lieu of an inclining experiment in the case of:

a) An individual yacht, provided basic stability data are available from the inclining experiment of a sister ship and a lightweight check is performed in order to prove that the sister ship corresponds to the prototype yacht. In such case the Society is satisfied when the result of the lightweight check shows a deviation from the displacement of the prototype yacht not greater than 2%, and not greater than 1% of the length between perpendiculars for the longitudinal position of the centre of gravity. The final stability data to be considered for the sister ship in terms of displacement and position of the centre of gravity are those of the prototype

b) On a case by case basis and subject to the agreement of the flag Administration, provided that:

   - a detailed list of weights, and the positions of their centre of gravity is submitted
   - a lightweight check is carried out, showing accordance between the estimated values and those determined
   - adequate stability is demonstrated in all the loading conditions reported in the trim and stability booklet.

2.2.5 Detailed procedure

A detailed procedure for conducting an inclining experiment is included in Ch 3, App 1. For the lightweight check, the same procedure applies except as provided for in Ch 3, App 1, [1.1.3], Ch 3, App 1, [1.1.4] and Ch 3, App 1, [1.1.8].

Section 2 Intact Stability

1 General

1.1 Information to the Master

1.1.1 Stability booklet

Each yacht is to be provided with a stability booklet, approved by the Society, which contains sufficient information to enable the Master to operate the yacht in compliance with the applicable requirements contained in this Section.

Where any alterations are made to a yacht so as to materially affect the stability information supplied to the Master, amended stability information is to be provided. If necessary the yacht is to be re-inclined.

Stability data and associated plans are to be drawn up in the official language or languages of the issuing country. If the languages used are neither English nor French, the text is to include a translation into one of these languages.

The format of the trim and stability booklet and the information included are specified in Ch 3, App 2.

1.2 Permanent ballast

1.2.1 If used, permanent ballast is to be located in accordance with a plan approved by the Society and in a manner that prevents shifting of position. Permanent ballast is not to be removed from the yacht or relocated within the yacht without the approval of the Society. Permanent ballast particulars are to be noted in the yacht's stability booklet.

1.2.2 Permanent solid ballast is to be installed under the supervision of the Society.

2 Design criteria for all type of yachts

2.1 General intact stability criteria

2.1.1 General

The intact stability criteria specified from [2.1.2] to [2.1.6] are to be complied with for the loading conditions mentioned in Ch 3, App 2, [1.2].

However, the lightship condition not being an operational loading case, the Society may accept that part of the above-mentioned criteria are not fulfilled.

2.1.2 GZ curve area

The area under the righting lever curve (GZ curve) is to be not less than 0,055 m·rad up to θ = 30° angle of heel and not less than 0,09 m·rad up to θ = 40° or the angle of down flooding θ_f if this angle is less than 40°. Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40° or between 30°and θ_f, if this angle is less than 40°, is to be not less than 0,03 m·rad.

Note 1: θ_f is an angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight submerge. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open (see Ch 3, App 2, [1.3.3]).

2.1.3 Minimum righting lever

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

2.1.4 Angle of maximum righting lever

The maximum righting arm is to occur at an angle of heel preferably exceeding 30° but not less than 25°.

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

In cases of yachts with a particular design (multihull for example), the Society may accept an angle of heel θ_{max} less than 25° but in no case less than 10°, provided that the area "A" below the righting lever curve is not less than the value obtained, in m·rad, from the following formula:

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

where:

θ_{max} : Angle of heel, in degrees, at which the righting lever curve reaches its maximum.

2.1.5 Initial metacentric height

The initial metacentric height GM_0 is not to be less than 0,15 m.

2.1.6 Additional criteria for sailing yachts

In addition to the previous criteria, the following criteria are to be complied with:

- the metacentric height corrected by the free surface effects, is to be greater than or equal to 0,30 m
- the righting lever GZ is to be at least 0,50 m at an angle of heel equal to or greater than 50°

3 Weather criterion

3.1 Weather criterion within the scope of additional class notation STAB-WIND

3.1.1 General Additional class notation STAB-WIND

At the request of the Interested Party, the additional class notation **STAB-WIND** may be assigned in accordance with Pt A, Ch 1, Sec 2, [2.5] to yachts complying with the stability criteria of the present Article.

3.1.2 Application

These criteria supplements the stability criteria given in [2.1] for:

- motor yachts
- sailing yachts with lowered sails

The more stringent criteria of [2.1] and the weather criterion are to govern the minimum requirements.

3.1.3 Assumptions

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

- the yacht is subjected to a steady wind pressure acting perpendicular to the yacht's centreline which results in a steady wind heeling lever (ℓ_{w1})
- from the resultant angle of equilibrium (θ_0), the yacht is assumed to roll owing to wave action to an angle of roll (θ_1) to windward
- the yacht is then subjected to a gust wind pressure which results in a gust wind heeling lever (ℓ_{w2})
- free surface effects, as described in [4], are to be accounted for in the standard conditions of loading as set out in Ch 3, App 2, [1.2].

3.1.4 Criteria

Under the assumptions of [3.1.3], the following criteria are to be complied with:

- the area "b" is to be equal to or greater than area "a", where:

  a : Area above the GZ curve and below ℓ_{w2}, between θ_R and the intersection of ℓ_{w2} with the GZ curve

  b : Area above the heeling lever ℓ_{w2} and below the GZ curve, between the intersection of ℓ_{w2} with the GZ curve and θ_2

- the angle of heel under action of steady wind (θ_0) is to be limited to 16° or 80% of the angle of deck edge immersion, whichever is less.

3.1.5 Heeling levers

The wind heeling levers ℓ_{w1} and ℓ_{w2}, in m, referred to in [3.1.4], are to vary as the square cosine function of the yacht heel and are to be calculated as follows:

$$\ell_{W1} = \frac{PAZ}{1000 g\Delta}$$

and

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

where:

P : Defined in Tab 1

A : Projected lateral area in m^2, of the portion of the yacht above the waterline

Z : Vertical distance, in m, from the centre of A to the centre of the underwater lateral area or approximately to a point at one half the draught

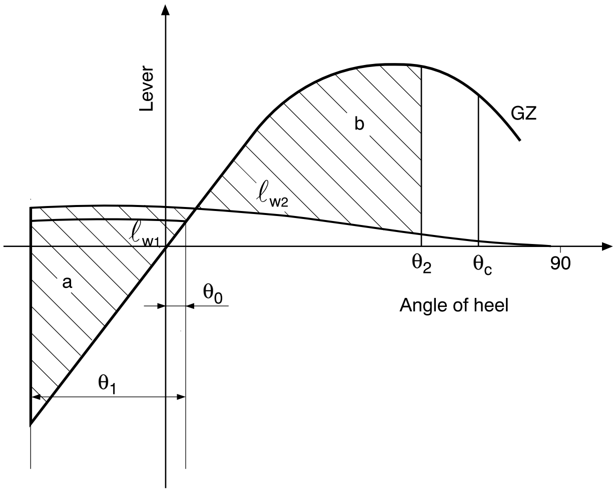
Δ : Displacement, in t

$g = 9{,}81\ m/s^2$

Table 1 : Wind pressure P

	$L_{LL} \le 70$ m	$L_{LL} > 70$ m
Unrestricted navigation or navigation limited to 60 nautical miles	reduced pressure according to [3.1.6]	504 N/m²
Restricted navigation	reduced pressure according to [3.1.6]	reduced pressure subject to the agreement of the Administration

Figure 1 : Severe wind and rolling



3.1.6 Calculation of the wind pressure

For yachts with a length equal or lesser than 70 m, the wind pressure P, in N/m², is to be calculated according to the following formula:

$$P = 504\left(\frac{H}{10}\right)^{1/3}$$

where:

H : Vertical distance, in m, from the waterline to the centre of A.

3.1.7 Angles of heel

For the purpose of calculating the criteria of [3.1.4], the angles in Fig 1 are defined as follows:

θ_0 : Angle of heel, in degrees, under action of steady wind

θ_1 : Angle of roll, in degrees, to windward due to wave action, calculated as follows:

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

θ_1 should be limited to 15° for the multihull

Note 1: For yachts with anti-rolling devices, θ_1 is to be determined without taking into account the operations of these devices.

Note 2: θ_1 may be obtained, in lieu of the above formula, from model tests or full scale measurements.

$\theta_R = \theta_0 - \theta_1$

θ_2 : Angle of downflooding θ_f in degrees, or 50° or θ_c, whichever is less

θ_f : Angle of heel, in degrees, at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. Small openings though which progressive flooding cannot take place need not be considered as open (see Ch 3, App 2, [1.3.3])

θ_c : Angle in degrees, of second intercept between wind heeling lever ℓ_{w2} and GZ curves

k : Coefficient equal to:

- k = 1,0 for a round-bilged yacht having no bilge or bar keels
- k = 0,7 for a yacht having sharp bilge
- k is defined in Tab 2 for a yacht having bilge keels, a bar keel or both

A_K : Total overall area, in m², of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas, or area of the lateral projection of any hull appendages generating added mass during yacht roll

X_1 : Coefficient defined in Tab 3

T_1 : Mean moulded draught in m, of the yacht

X_2 : Coefficient defined in Tab 4

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

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

s : Factor defined in Tab 5.

T_R : Rolling period, in s, is calculated as follows:

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

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

L_W : Length, in m, of the yacht at the waterline

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

Note 3: Intermediate values are to be obtained by linear interpolation from the values given in Tab 2 to Tab 5.

Table 2 : Values of coefficient k

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

Table 3 : Values of coefficient X_1

B/T_1	X_1
$\leq$ 2,4	1,00
2,5	0,98
2,6	0,96
2,7	0,95
2,8	0,93
2,9	0,91
3,0	0,90
3,1	0,88
3,2	0,86
3,4	0,82
$\geq$ 3,5	0,80

Table 4 : Values of coefficient X_2

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

Table 5 : Values of factor s

T_R	s
≤ 6	0,100
7	0,098
8	0,093
12	0,065
14	0,053
16	0,044
18	0,038
≥ 20	0,035

3.2 Weather criterion for sailing yachts

3.2.1 Application

For all the operational loading conditions of Ch 3, App 2, [1.2], the wind moment based on the three sailing combinations as described in [3.2.2], is to be calculated according to [3.2.4]. Each condition is to comply with the criteria listed in [3.2.5].

3.2.2 The three sailing combinations which have to be investigated are:

- full sails
- intermediate sails
- reduced sails.

3.2.3 The wind force, in N, should be calculated as follows:

$F = 1/2\ C_s\ \rho\ A\ V^2$

where:

C_s	:	Shape coefficient. Without specific available data, this coefficient is to be taken equal to 1,1
ρ	:	Air mass density, equal to 1,222 kg/m^3
A	:	Projected area of all the exposed surfaces, in m^2
V	:	Maximum wind speed, in m/s, for which the yacht is able to operate for each specific combination of sails as described in [3.2.2].

3.2.4 The wind moment is the force F as calculated in [3.2.3], multiplied by the heeling lever Z. The heeling lever Z is the vertical distance, in m, from the centre of A to the centre of the underwater lateral area or approximately to a point at one half the draught.

The corresponding wind heeling lever is calculated as follows:

$\lambda = ((F.Z)/(9807.\Delta)).(\cos\theta)^2$

3.2.5 Criteria

Under the assumptions of [3.2.4], the following criteria are to be complied with:

- the angle of the static heel due to the effect of wind is to be limited to 20° or 90% of the immersion of the deck, whichever is less
- the area above the wind heeling lever λ and below the GZ curve, between the angle of static wind heel and the downflooding angle, is to be at least equal to 0,065 m·rd.

4 Effects of free surfaces of liquids in tanks

4.1 General

4.1.1 For all loading conditions, the initial metacentric height and the righting lever curve are to be corrected for the effect of free surfaces of liquids in tanks.

4.2 Consideration of free surface effects

4.2.1 Free surface effects are to be considered whenever the filling level in a tank is equal to or less than 98% of full condition. Free surface effects need not be considered where a tank is nominally full, i.e. filling level is above 98%. Nevertheless, in order to take into account the consumption of consumable just after departure, the requirement of [4.2.2] is to be considered.

4.2.2 In calculating the free surface effects in tanks containing consumable liquids, it is to be assumed that, for each type of liquid, at least one transverse pair or a single centreline tank has a free surface and the tank or combination of tanks taken into account are to be those where the effect of free surface is the greatest.

4.3 Water ballast tanks

4.3.1 Where water ballast tanks are to be filled or discharged during the course of a voyage, the free surface effect is to be calculated to take account of the most onerous transitory stage relating to such operations.

4.4 GM_0 and GZ curve corrections

4.4.1 The corrections to the initial metacentric height and to the righting lever curve are to be addressed separately as indicated in [4.4.2] and [4.4.3].

4.4.2 In determining the correction to the initial metacentric height, the transverse moments of inertia of the tanks are to be calculated at 0° angle of heel.

4.4.3 The righting lever curve may be corrected by any of the following methods:

- correction based on the actual moment of fluid transfer for each angle of heel calculated
- correction based on the moment of inertia, calculated at 0° angle of heel, modified at each angle of heel calculated.

4.4.4 Whichever method is selected for correcting the righting lever curve, only that method is to be presented in the yacht’s trim and stability booklet. However, where an alternative method is described for use in manually calculated loading conditions, an explanation of the differences which may be found in the results, as well as an example correction for each alternative, are to be included.

4.5 Remainder of liquid

4.5.1 The usual remainder of liquids in the empty tanks need not be taken into account in calculating the corrections, providing the total of such residual liquids does not constitute a significant free surface effect.

5 Icing

5.1 Application

5.1.1 For any yacht operating in areas where ice accretion is likely to occur, adversely affecting a yacht's stability, attention is to be paid to the effect of the ice. The additional standard calculations taking into account the icing areas are to be supplied.

5.2 Calculation assumptions

5.2.1 For yachts operating in areas where ice accretion is likely to occur, the following icing allowance is to be made in the stability calculations:

- 30 kg/m^2 on exposed weather decks and gangways
- 7,5 kg/m^2 for the projected lateral area of each side of the ship above the water plane
- the projected lateral area of discontinuous surfaces of rail, sundry booms, spars (except masts) and rigging of ships having no sails and the projected lateral area of other small objects are to be computed by increasing the total projected area of continuous surfaces by 5% and the static moments of this area by 10%.

5.2.2 Yachts intended for operation in areas where ice is known to occur are to be:

- designed to minimise the accretion of ice, and
- equipped with such means for removing ice as, for example, electrical and pneumatic devices, and/or special tools such as axes or wooden clubs for removing ice from bulwarks, rails and erections.

5.3 Guidance relating to ice accretion

5.3.1 The following icing areas are to be considered:

a) the area north of latitude 65°30'N, between longitude 28°W and the west coast of Iceland; north of the north coast of Iceland; north of the rhumb line running from latitude 66°N, longitude 15°W to latitude 73°30'N, longitude 15°E, north of latitude 73°30'N between longitude 15°E and 35°E, and east of longitude 35°E, as well as north of latitude 56°N in the Baltic Sea

b) the area north of latitude 43°N bounded in the west by the North American coast and the east by the rhumb line running from latitude 43°N, longitude 48°W to latitude 63°N, longitude 28°W and thence along longitude 28°W

c) all sea areas north of the North American Continent, west of the areas defined in a) and b)

d) the Bering and Okhotsk Seas and the Tartary Strait during the icing season, and

e) south of latitude 60°S.

5.3.2 For yachts operating where ice accretion may be expected:

- within the areas defined in a), c), d) and e) of [5.3.1] known to having icing conditions significantly different from those described in [5.2], ice accretion requirements of one half to twice the required allowance may be applied
- within the area defined in b), where ice accretion in excess of twice the allowance required by [5.2] may be expected, more severe requirements than those given in [5.2] may be applied.

Section 3 Damage Stability

1 General

1.1 Application

1.1.1 Yachts having the navigation notation **unrestricted navigation** and a length L_{LL} greater than 24 m but less than 85 m are to meet the damage stability requirements of this Section.

1.1.2 Yachts having the navigation notation **unrestricted navigation** and a length L_{LL} equal to or greater than 85 m are to meet the damage stability requirements of the SOLAS 90 for one compartment (Chapter II-1, Part B, Reg.8 [2.3] to [6]) according to the deterministic method.

1.1.3 Yachts having the navigation notation **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, and yachts under 300 UMS not engaged in trade are exempted from damage stability requirements.

2 Assumptions

2.1 Description of the damage

2.1.1 Extent of damage

The damage should occur anywhere along the yacht's length (from the baseline up to the level of the waterline), except in way of a watertight bulkhead. Only one compartment or one tank is considered as damaged at one time.

However, if a down-flooding or progressive flooding may occur through pipework, ventilation ducts, doors, hatches or any other non-watertight openings, the flooding of the concerned compartments should be considered.

2.2 Method of calculation

2.2.1 Lost buoyancy method

The damage stability calculations are to be performed using the lost buoyancy method (constant displacement).

2.2.2 Treatment of liquids

When a tank containing liquid is damaged, the tank is emptied of its contents and floods with sea water (SG = 1,025) up to the level of the final plane of equilibrium.

2.3 Permeabilities

2.3.1 General

For the purpose of the damage stability calculations, the following permeabilities are to be considered:

- accommodation or voids: 0,95
- machinery: 0,85
- stores: 0,60
- liquids: 0 to 0,95 (see [2.2.2]).

2.4 Inclining moment

2.4.1 The moment due to the wind pressure is to be considered as follows:

- a wind pressure of 120 N/m^2 is to be applied
- the area applicable is to be the projected lateral area of the yacht above the waterline corresponding to the intact condition. For sailing yachts, the sails are to be considered lowered
- the moment arm is to be the vertical distance from a point at one half of the mean draught corresponding to the intact condition to the centre of gravity of the lateral area.

2.5 Damage stability criteria

2.5.1 The following damage stability criteria are to be complied with:

a) in the case of symmetrical flooding due to compartment arrangement, a positive residual metacentric height is to be at least 50 mm as calculated by the constant displacement method

b) in the case of unsymmetrical flooding, the angle of heel is not to exceed 7°. For multihull yachts, an angle of heel up to 10° may be accepted

If arrangements are necessary to minimize the angle of heel, the means adopted are, where practicable, to be self-acting but in any case, where controls to cross-flooding fittings are provided, they are to be operable from above the bulkhead deck. Suitable information concerning the use of cross-flooding fittings are to be supplied (see Note 1). The total time for equalization is not to exceed 15 minutes

Note 1: Refer to the standard method of calculation according to the IMO Resolution.

c) the bulkhead deck line is not to be submerged at the equilibrium, except if it exits an enclosed superstructure as defined in Ch 2, Sec 2, [2.2.3]; in this case, the safety clearance is to be at least 1 m below all openings through which flooding could take place

d) the minimum range of the positive residual righting lever curve is to be at least 15° beyond the angle of equilibrium

e) the area under the righting lever curve is to be at least 0,015 m·rd measured from the angle of equilibrium to the lesser of the angle at which progressive flooding occurs, and 22° measured from upright

f) a residual righting lever of 0,1 m is to be obtained within the range of positive stability.

Appendix 1 Inclining Experiment and Weighing Test

1 Inclining experiment and lightweight check

1.1 General

1.1.1 The procedure from [1.1.3] to [1.1.8] is to be applied. For multihull or sailing yachts, the same procedure applies except as provided for [1.1.3], [1.1.4] and [1.1.8]. The requirements of [1.1.8] are to be examined on a case by case basis. As an alternative to [1.1.8], a detailed list of the weights with their centre of gravity is to be submitted to the Society.

Prior to the experiment, the procedure of the inclining experiment is to be submitted to the Society, for examination.

The report of the inclining experiment is to be signed by the attending Society's Surveyor, in order to confirm all the input data such as density of sea water, draught readings, deflection of the pendulum.

1.1.2 General conditions of the yacht

The Society's Surveyor is to be satisfied of the following:

- the weather conditions are to be favorable
- the yacht is to be moored in a quiet, sheltered area free from extraneous forces, such as to allow unrestricted heeling. The yacht is to be positioned in order to minimize the effects of possible wind, stream and tide
- the yacht is to be transversely upright and the trim is to be taken not more than 1% of the length between perpendiculars. Otherwise, hydrostatic data and sounding tables are to be available for the actual trim
- lifesaving appliances capable of inducing oscillations are to be secured
- the system containing liquids such as pipes, are to be filled
- the bilge and the decks are to be thoroughly dried
- preferably, all tanks are to be empty and clean, or completely full. The number of tanks containing liquids is to be reduced to a minimum taking into account the above-mentioned trim. In particular the filling of slack tanks is to be less than 80% to avoid any influence of structural elements. The shape of the tank is to be such that the free surface effect can be accurately determined and remain almost constant during the experiment. All cross connections are to be closed
- the weights necessary for the inclination are to be already on board, located in the correct place
- all work on board is to be suspended and crew or personnel not directly involved in the inclining experiment is to leave the yacht
- the yacht is to be as complete as possible at the time of the experiment. The number of weights to be removed added or shifted is to be limited to a minimum. Temporary material, tool boxes, staging, sand, debris, etc., on board is to be reduced to an absolute minimum
- lifting keels have to be located on the highest position. Canting keels have to be upright and cannot be used as shifting weights.

1.1.3 Inclining weights

The total weight should be sufficient to provide a minimum inclination of two degrees and a maximum of four degrees of heel to each side. However, a minimum inclination of one degree to each side may be accepted for multihull or sailing yachts, provided that the requirement on pendulum deflection or U-tube difference in height specified in [1.1.4] is complied with. Test weights are to be compact and of such a configuration that the VCG (vertical centre of gravity) of the weights can be accurately determined. Each weight is to be marked with an identification number and its weight. Re-certification of the test weights is to be carried out prior to the incline. A crane of sufficient capacity and reach, or some other means, is to be available during the inclining experiment to shift weights on the deck in an expeditious and safe manner. If the yacht has water ballast tanks, water ballast cannot be used as inclining weight.

1.1.4 Pendulums

The use of two pendulums is requested to allow identification of bad readings at any one pendulum station. However, for yachts of a length equal to or less than 30 m, only one pendulum can be accepted. They are each to be located in an area protected from the wind. The pendulums are to be long enough to give a measured deflection, to each side of upright, of at least 10 cm. To ensure recordings from individual instruments are kept separate, it is suggested that the pendulums be physically located as far apart as practical.

The use of an inclinometer or U-tube is to be considered in each separate case. It is recommended that inclinometers or other measuring devices only be used in conjunction with at least one pendulum.

1.1.5 Means of communications

Efficient two-way communications may be provided between central control and the weight handlers, and between central control and each pendulum station. One person at a central control station is to have complete control over all personnel involved in the experiment. The internal means of communication inside the yacht may be used for this purpose.

1.1.6 Documentation

The person in charge of the inclining experiment is to have available a copy of the following plans at the time of the experiment:

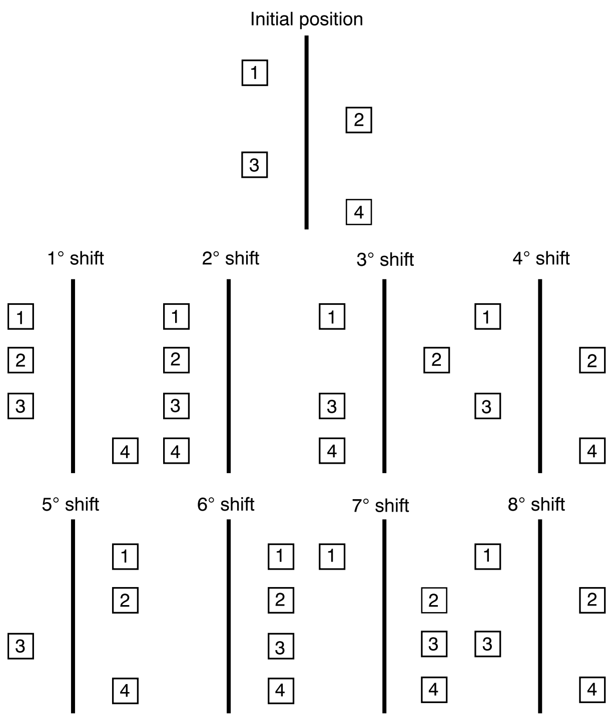
- hydrostatic curves or hydrostatic data
- general arrangement plan of decks, holds, inner bottoms, etc.
- capacity plan showing capacities and vertical and longitudinal centres of gravity of cargo spaces, tanks, etc.
- tank sounding tables
- draught mark locations
- docking drawing with keel profile and draught mark corrections (if available).

1.1.7 Determination of the displacement

The Society's Surveyor is to carry out all the operations necessary for the accurate evaluation of the displacement of the yacht at the time of the inclining experiment, as listed below:

- draught mark readings are to be taken at aft and forward, at starboard and port sides.These draughts are also to be taken at midship, as far as practicable
- the mean draught (average of port and starboard readings) is to be calculated for each of the locations where draught readings are taken and plotted on the yacht's lines drawing or outboard profile to ensure that all readings are consistent and together define the correct waterline. The resulting plot is to yield either a straight line or a waterline which is either hogged or sagged. If inconsistent readings are obtained, the freeboards/ draughts are to be retaken
- the specific gravity of the sea water is to be determined. Samples are to be taken from a sufficient depth of the water to ensure a true representation of the sea water and not merely surface water, which could contain fresh water from run off of rain. A hydrometer is to be placed in a water sample and the specific gravity read and recorded. Where the value of the average calculated specific gravity is different from that reported in the hydrostatic curves, adequate corrections are to be made to the displacement curve
- all double bottoms, as well as all tanks and compartments which can contain liquids, are to be checked, paying particular attention to air pockets which may accumulate due to the yacht's trim and the position of air pipes, and also taking into account the provisions of [1.1.2]
- the possible solid permanent ballast is to be clearly identified and listed in the report
- the yacht should be as upright as possible and have sufficient draught so that any abrupt changes in the waterplane will be avoided as the yacht is inclined from side to side. A deviation from design trim of up to 1% of LLL is normally acceptable when using hydrostatic data calculated at design trim. Otherwise, the hydrostatic data should be calculated for the actual trim. With inclining weights in the initial position, up to one-half degree of list is acceptable.

Figure 1 : Weight shift procedure



1.1.8 The incline

The standard experiment generally employs eight distinct weight movements as shown in Fig 1.

The weights are to be transversely shifted, so as not to modify the yacht's trim and the vertical position of the centre of gravity.

After each weight shifting, the new position of the transverse centre of gravity of the weights is to be accurately determined.

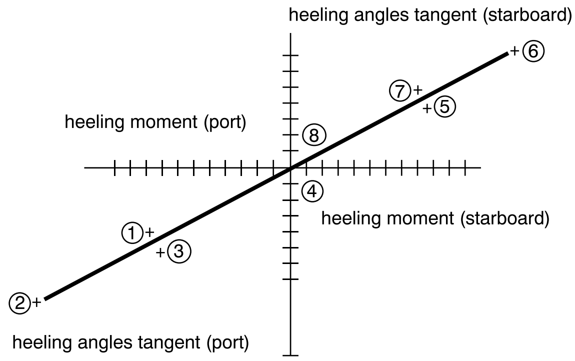
After each weight movement, the distance the weight was moved (centre to centre) is to be measured and the heeling moment calculated, multiplying the distance by the amount of weight moved. The tangent is calculated for each pendulum, dividing the deflection by the length of the pendulum. The resultant tangents are plotted on the graph as shown in Fig 2.

The pendulum deflection is to be read when the yacht has reached a final position after each weight shifting.

During the reading, no movement of personnel is allowed.

For yachts with a length equal to or less than 30 m, six distinct weight movements may be accepted.

Figure 2 : Graph of resultant tangents



Appendix 2 Trim and Stability Booklet

1 Trim and stability booklet

1.1 Information to be included in the trim and stability booklet

1.1.1 General

A trim and stability booklet is a stability manual, to be approved by the Society, which is to contain sufficient information to enable the Captain to operate the yacht in compliance with the applicable requirements contained in the Rules.

The format of the stability booklet and the information included vary depending on the yacht type and operation.

1.1.2 List of information

The following information is to be included in the trim and stability booklet:

- a general description of the yacht, including:
  - the yacht's name and the Society classification number
  - the yacht type and service notation
  - the class notations
  - the yard, the hull number and the year of delivery
  - the moulded dimensions
  - the draught corresponding to the full load waterline (defined in Ch 1, Sec 2, [2.6])
  - the displacement corresponding to the above-mentioned draught
- clear instructions on the use of the booklet
- general arrangement and capacity plans indicating the assigned use of compartments and spaces (stores, accommodation, etc.)
- a sketch indicating the position of the draught marks referred to the yacht's perpendiculars
- hydrostatic curves or tables corresponding to the design trim, and, if significant trim angles are foreseen during the normal operation of the yacht, curves or tables corresponding to such range of trim are to be introduced. A clear reference relevant to the sea density, in t/m^3, is to be included as well as the draught measure (from keel or under keel)
- cross curves (or tables) of stability calculated on a free trimming basis, for the ranges of displacement and trim anticipated in normal operating conditions, with indication of the volumes which have been considered in the computation of these curves
- tank sounding tables or curves showing capacities, centres of gravity, and free surface data for each tank
- lightship data from the inclining experiment, as indicated in Ch 3, Sec 1, [2.2], including lightship displacement, centre of gravity co-ordinates, place and date of the inclining experiment, as well as the Society approval details specified in the inclining experiment report. It is suggested that a copy of the approved experiment report be included

  Where the above-mentioned information is derived from a sister ship, the reference to this sister ship is to be clearly indicated, and a copy of the approved inclining experiment report relevant to this sister ship is to be included
- standard loading conditions as indicated in [1.2] and examples for developing other acceptable loading conditions using the information contained in the booklet
- intact stability results (total displacement and its centre of gravity co-ordinates, draughts at perpendiculars, GM, GM corrected for free surfaces effect, GZ values and curve, criteria as indicated in Ch 3, Sec 2, reporting a comparison between the actual and the required values) are to be available for each of the above-mentioned operating conditions. The method and assumptions to be followed in the stability curve calculation are specified in [1.3]
- damage stability results (total displacement and its maximum permissible centre of gravity height, draughts at perpendiculars, GM, GM corrected for free surfaces effect, GZ values and curve, criteria as indicated in Ch 3, Sec 3, reporting a comparison between the actual and the required values) are to be available for each of the above-mentioned operating conditions. The method and assumptions to be followed in the stability curve calculation are specified in [1.3]
- maximum KG or minimum GM curve or table which can be used to determine compliance with the applicable intact and damage stability criteria when applicable
- information about openings (location, tightness, means of closure), pipes or other progressive flooding sources. The opening used for the calculation of the down flooding angle has to be clearly identified
- information concerning the use of any special cross-flooding fittings with descriptions of damage conditions which may require cross-flooding, when applicable
- any other necessary guidance for the safe operation of the yacht, in particular, limitations regarding maximum allowable wind pressure as calculated in Ch 3, Sec 2, [3]
- a table of contents and index for each booklet.

1.2 Loading conditions

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

- yacht in the light condition
- yacht in the fully loaded departure condition with full stores and fuel and with full number of passengers with their luggage
- yacht in the fully loaded arrival condition, with full number of passengers and their luggage but with only 10% stores and fuel remaining.

1.3 Stability curve calculation

1.3.1 General

Hydrostatic and stability curves are normally prepared on a designed trim basis. However, where the operating trim or the form and arrangement of the yacht are such that change in trim has an appreciable effect on righting arms, such change in trim is to be taken into account.

1.3.2 Superstructures, deckhouses and other structures which may be taken into account

Enclosed superstructures complying with Ch 2, Sec 2, [2.2.3] may be taken into account.

1.3.3 Angle of flooding

In cases where the yacht would sink due to flooding through any openings, the stability curve is to be cut short at the corresponding angle of flooding and the yacht is to be considered to have entirely lost its stability.

Small openings such as those for passing wires or chains, tackle and anchors, and also holes of scuppers, discharge and sanitary pipes are not to be considered as open if they submerge at an angle of inclination more than 30°. If they submerge at an angle of 30° or less, these openings are to be assumed open if the Society considers this to be a source of significant progressive flooding; therefore such openings are to be considered on a case by case basis.

Part B
Hull and Stability

CHAPTER 4
DESIGN LOADS

Section 1 General

1 Application

1.1 General

1.1.1 The type of loads taken into account in the present rules are:

- global hull girder loads: used for the determination of the global hull girder strength
- local loads: used for the determination of the local strength of plate panel, ordinary and primary stiffeners.

These loads are not to be amplified by any safety factor, such safety factors being included in the permissible stresses considered for the structure scantling.

1.1.2 As a general rule, the wave loads and the ship motions and accelerations defined in the present Chapter are based on wave environment as defined in Ch 1, Sec 1, [1.1.3] corresponding to a probability level as defined in Ch 1, Sec 1, [1.1.4].

1.1.3 As an alternative to the present Chapter, the Society may accept the values of ship motions and accelerations derived from direct calculations or obtained from model tests, when justified on the basis of the ship characteristics and intended service. In general, the values of ship motions and accelerations to be determined are those which can be reached with the probability level defined in [1.1.2]. In any case, the model tests or the calculations, including the assumed sea scatter diagrams and spectra, are to be submitted to the Society for approval.

2 Global hull girder loads

2.1 General

2.1.1 The global hull girder loads considered are a combination of the following loads:

- still water hull girder loads, resulting from the effect of the difference in downwards ship weights forces and upwards buoyancy forces along the hull
- wave hull girder loads, incident to the buoyancy forces variations induced by the waves on the hull
- digging in wave loads (for catamaran), induced by the buoyancy forces located in the fore part of the floats of catamaran due to digging in wave
- maximum rigging loads (for sailing yacht), induced by the loads exerted by the standing rigging on the hull for the different sailing conditions (forces induced by lift and drag sailing loads, inertia due to ship accelerations, pre-tensioning forces...).

2.1.2 Specific yachts

For yacht having unusual features, the Society may consider direct calculations of global hull girder loads. In such case, wave characteristics taken into account are to comply with the requirements of Ch 4, Sec 2, [3.2.2] and/or Ch 4, Sec 2, [3.3.2] and the calculations are to be submitted to the Society.

2.2 Still water and wave loads

2.2.1 The global hull girder loads induced by still water and wave loads are forces and moments which result as effects of local loads acting on the hull as a whole and considered as a beam.

2.2.2 As a rule, the global hull girder loads are to be taken into consideration in the following cases:

a) Monohull and float of multihull:
   - yacht with important length L_W (greater than 40 m for yachts built in steel or aluminium alloys and greater than 30 m for yachts built in composite materials), or
   - sailing yacht submitted to important forces induced by the mast and by the standing rigging, or
   - yacht having large openings in decks or significant geometrical structure discontinuity at bottom or decks, or
   - yacht with transverse framing system, or
   - yacht with deck structure made of small plate thicknesses and large spacing of secondary stiffeners
   - for yacht built in HDPE, according to NR546 Composite Ships, Sec 10
   - where deemed appropriate by the Society.

   For yachts not covered by the above cases, the hull girder strength is considered satisfied when local scantlings are in accordance with the present Rules.

b) Platform structure of multihull:

   As a rule, the global transverse strength of platform of multihull is to be examined for all types of multihull.

2.3 Digging in wave loads for catamaran

2.3.1 As a rule, the digging in wave loads are to be considered for the structure scantling check of catamaran.

This loading case corresponds to the situation where the catamaran sails in quartering head sea and has the fore end of the floats burying themselves into the encountered waves.

2.3.2 The global loads induced by the digging in wave are based on the following navigation hypothesis:

- 10° longitudinal trim
- 10° transverse heel
- 1g digging in horizontal deceleration
- the floats digging into water are submerged from the fore end of the floats until the forward part of the catamaran platform.

Note 1: Multihulls with more than two floats are not covered by the present Section and are to be examined on a case by case basis.

2.4 Global rigging loads

2.4.1 The global rigging loads are generally to be considered for the structure scantling check of sailing yachts where:

- mast, stays, shrouds and backstay induce significant loads in the hull girder, or
- main deck is provided with large openings or significant structural discontinuity, or
- main deck is provided with transverse framing system.

2.4.2 The rigging loads considered in the present Section are the forces induced mainly by the mast, the stays, the vertical and the lower shrouds and the backstay.

Note 1: The loads induced by the running rigging are not taken into account in the global rigging loads, except for the main sail sheet force which is to be added to the backstay value.

These standing rigging loads are to be defined by the Yard and/or the Designer for normal navigation conditions taking into account the:

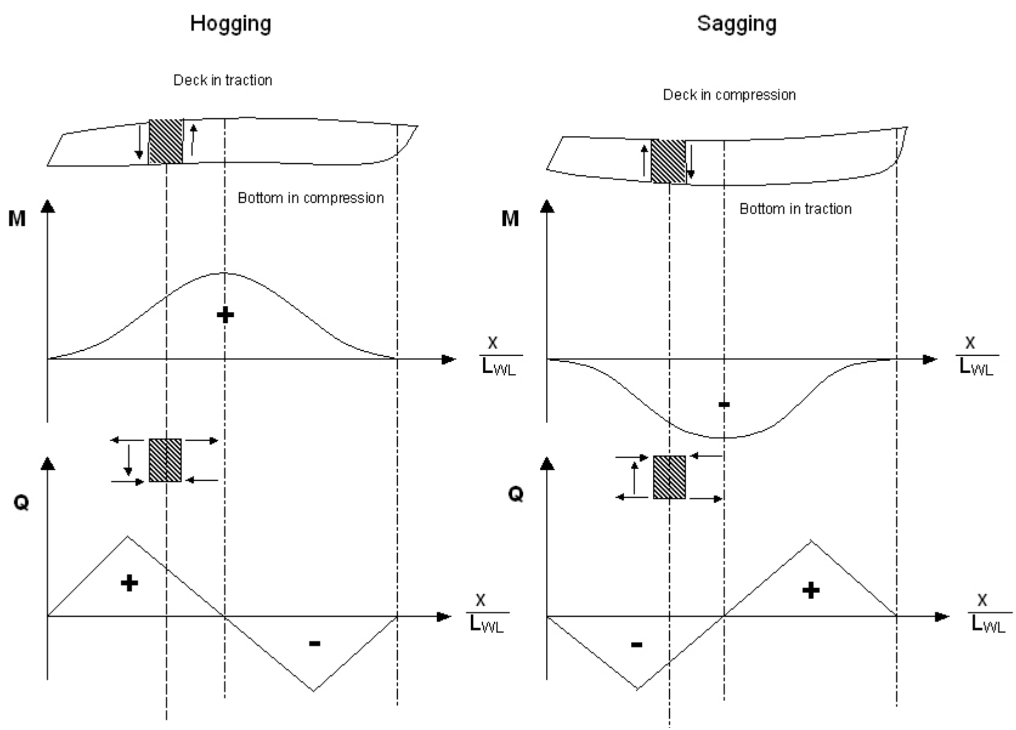
- sails reduction versus apparent wind speed
- sails configuration for all wind heading from head wind to down wind
- longitudinal and transversal inertia loads induced by ship motions.

2.4.3 Where the standing rigging loads are not defined by the designer, these loads may be determined from the sizing of shrouds provided on board. In such case, the rig loads considered are the breaking loads of the shrouds, divided by a coefficient equal to 2,5 (this coefficient is generally the safety factor on breaking loads used for the design of shrouds).

Note 1: The Society may consider a different value for this coefficient, on a case by case basis, upon satisfactory justification given by the Yard and/or the Designer.

2.4.4 The global rigging loads are defined in Ch 4, Sec 2, [5].

Figure 1 : Sign conventions for shear forces Q and bending moments M



2.5 Sign conventions of vertical bending moments and shear forces

2.5.1 Except where specified in Ch 5, Sec 9 and in Ch 5, Sec 10, the sign conventions of bending moments and shear forces induced by global loads at any ship transverse section are as shown in Fig 1:

- the vertical bending moment M is positive when it induces tensile stresses in the strength deck (hogging bending moment) and is negative in the opposite case (sagging bending moment)
- the vertical shear force Q is positive if the resulting forces aft of the ship transverse section under consideration is downward and is negative in the opposite case.

3 Local loads

3.1 Type of loads

3.1.1 The local loads are the pressures or the forces which are directly applied to the individual structural members (plating panels, ordinary and primary stiffeners).

3.1.2 Local loads considered in the present Rules are:

- local sea pressure loads, constituted by the wave loads calculated in full load condition of the yacht
- local dynamic pressure, constituted by the:
  - slamming pressures on the hull bottom induced by the relative motion and velocity of the yacht in irregular waves, and
  - impact pressure on the side shell induced by sea impact on the hull
- localized loads, constituted by localized forces exerted on yacht's structure, such as, e.g., loads induced by standing rigging and main sail sheet, solid keel, etc.
- internal pressures in spaces intended to carry liquid
- flooding loads
- test loads constituted by pressures exerted during hydrostatic tests of spaces intended to carry liquids.

3.1.3 The local sea pressure loads, in KN/m^2, are defined in Ch 4, Sec 3.

4 Navigation coefficients

4.1 General

4.1.1 Navigation coefficient

A reduction coefficient n, as defined in Tab 1, is considered on global and local loads to take into account the navigation area and the notation of the yacht within the scope of classification and/or certification as defined in Pt A, Ch 1, Sec 2, [2.4].

Table 1 : Navigation coefficients

Navigation notation	Navigation coefficient n
unrestricted navigation or navigation limited to 60 nautical miles	1,00
coastal area	0,80
sheltered area	0,65

Section 2 Global Hull Girder Loads

Symbols

L_{HULL} : Hull length, as defined in Ch 1, Sec 2, [2.2.2], in m

L_{WL} : Length at waterline at full load, in m, as defined in Ch 1, Sec 2, [2.2.3]

M_{SW} : Still water vertical bending moment, in kN.m, defined in [2], having the following value:

- $M_{SW,H}$ when the yacht is in hogging condition
- $M_{SW,S}$ when the yacht is in sagging condition

Q_{SW} : Still water vertical shear force, in kN, defined in [2]

M_{WV} : Wave vertical bending moment, in kN.m, defined in [3]

Q_{WV} : Wave vertical shear force, in kN, defined in [3]

n : Navigation coefficient defined in Ch 4, Sec 1, [4]

C_B : Total block coefficient as defined in Ch 1, Sec 2, [2.7].

1 Application

1.1 General

1.1.1 When deemed necessary by the Society as indicated in Ch 4, Sec 1, [2], the following global hull girder loads are to be considered:

- for monohull:
  - still water loads and wave loads as defined in [2] and [3],
  - in addition for sailing monohull, rig loads as defined in [5.1] or [5.2].
- for catamaran:
  - still water loads and wave loads as defined in [2] and [3] taking into account [3.2.3], and
  - digging in wave loads as defined in [4]
  - in addition for sailing catamaran, rig loads as defined in [5.3].

Note 1: The vertical moments and shear forces induced by waves, and those considered in the digging in wave case, are only defined in the present Section for monohull and catamaran. For multihull with more than two floats, these moments and shear forces are defined on a case by case basis.

1.1.2 These different hull girder loads are to be combined as defined in Ch 5, Sec 4 (for yachts built in steel or aluminium alloys) or Ch 6, Sec 4 (for yachts built in composite materials) in order to check the longitudinal hull girder scantlings and, in addition for catamaran, the transverse structure of platform.

2 Still water loads

2.1 Longitudinal bending moments and shear forces

2.1.1 The longitudinal distribution of still water bending moments and shear forces are to be submitted by the designer or the yard for the following loading conditions:

- yacht with 100% full capacities
- yacht with 10% capacities.

2.1.2 The lines plan, the lightweight distribution and the capacity plan considered for the determination of the longitudinal distribution of still water bending moments and shear forces may be requested for information.

2.1.3 When the information required in [2.1.1] are not available, the still water bending moments M_{SW} and shear forces Q_{SW} may be taken as defined in Tab 1 as a guideline for preliminary assessment only.

For ships having a superstructure distribution all along the ship length or located in the midship area from 0,3 L_{WL} to 0,7 L_{WL} from the aft end, the maximum bending moments and the maximum shear forces in hogging conditions may be reduced by 40%.

The distribution of the still water bending moments and the shear forces may be taken as the same as the distribution of the vertical wave bending moments and the wave shear forces defined in [3.2.4].

Table 1 : Still water bending moments (M_{SW}) and shear forces (Q_{SW}) for preliminary assessment

Type of yachts	M_{SW}	Q_{SW}
Monohull conventional motor yachts **(1)**	$M_{SW,H} = 0{,}8\ M_{WV}$	$Q_{SW} = 0{,}8\ Q_{WV}$
Monohull motor yachts with large transom **(1) (3)**	$M_{SW,H} = 0{,}4\ M_{WV}$	$Q_{SW} = 0{,}4\ Q_{WV}$
Catamaran motor yacht **(1)**	$M_{SW,H} = 0{,}8\ M_{WV}$	$Q_{SW} = 0{,}8\ Q_{WV}$
Monohull sailing yacht **(2)**	$M_{SW,S} = 0{,}2\ M_{WV}$	$Q_{SW} = 0{,}2\ Q_{WV}$
Catamaran sailing yacht **(1)**	$M_{SW,H} = 0{,}8\ M_{WV}$	$Q_{SW} = 0{,}8\ Q_{WV}$
M_{WV}, Q_{WV}: Wave vertical bending moment and wave vertical shear force as defined in [3.2.1], without taking into account [3.2.3] for catamaran **(1)** Still water bending moment are always considered in hogging condition, resulting in tensile stress in the deck **(2)** Still water bending moment are always considered in sagging condition, resulting in compression stress in the deck **(3)** Motor yachts with large transom are ships having a high buoyancy at the aft part of the hull. As a rule, the transom is to fulfill the two following conditions: • water breath of the transom is greater than 0.75 B_{WL}, and • the transom height under water is greater than 0,65 T		

3 Wave loads

3.1 General

3.1.1 Wave loads induced by encountered waves in head sea or quartering sea conditions are defined in [3.2] and [3.3].

3.1.2 The vertical bending moments and shear forces induced by wave are calculated according to the following hypothesis:

- For monohull and catamaran:

  In head sea condition: the forward and the aftward perpendicular of the hull are on the crest, or on the trough, of the wave

- In addition for catamaran:

  In quartering sea condition: the forward perpendicular of one float and the aftward perpendicular of the other float are on the crest of the wave.

3.2 Head sea condition for monohull and catamaran

3.2.1 Bending moment and shear force

The maximum values of the vertical wave bending moment M_{wv}, in kN.m, and the shear force Q_{wv}, in kN, along the hull or the float in head sea condition are obtained from the following formulas:

$$M_{WV} = 0{,}20\ n\ C_W\ L_W^2\ B_{WL}\ C_B$$

$$Q_{WV} = 0{,}65\ n\ C_W\ L_W\ B_{WL}\ C_B$$

where:

C_W : Wave parameter, in m, as defined in [3.2.2]

L_W : Wave length, in m, as defined in [3.2.2]

B_{WL} : Maximum breadth at waterline, in m, of the hull.

For catamaran, B_{WL} is to be taken equal to the maximum breath at waterline of one float.

3.2.2 Wave characteristics for head sea condition

The characteristics of the encountered equivalent static wave to consider in head sea condition are as follows:

- sinusoïdal type
- wave length L_W ,in m, equal to: $L_W = 0{,}5\ (L_{WL} + L_{HULL})$
- wave parameter C_W , in m, equal to: $C_W = 0{,}625\ (118 - 0{,}36\ L_W)\ L_W\ 10^{-3}$

3.2.3 Additional requirements for catamaran

For catamaran, the maximum values of vertical wave bending moment M_{wv} and shear force Q_{wv} calculated according to [3.2.1], corresponding to the loads applied to one float only, are to be increased by:

- 10% for motor yacht catamaran,
- 30% for sailing yacht catamaran.

3.2.4 Distribution

The hull girder loads in head sea conditions defined in [3.2] are to be applied along the ship from 0,3 L_{WL} from the aft end to 0,7 L_{WL} from the aft end.

Note 1: As a rule, the distribution of hull girder loads from the aft perpendicular to 0,3 L_{WL} and from 0,7 L_{WL} to the fore perpendicular are overlooked and considered as equal to zero.

3.3 Quartering sea condition for catamaran

3.3.1 Wave torque moment

The maximum value of the wave bending moment M_{WT}, in KN.m, along the floats of catamaran in quartering sea condition are obtained from the following formulas:

$M_{WT} = n\ C_{WQ}\ L_W^2\ B_{WL}\ C_B$

where:

C_{WQ} : Wave parameter, in m, as defined in [3.3.2]

L_W : $L_W = 0{,}5\ (L_{WL} + L_{HULL})$

B_{WL} : Maximum breadth at waterline of one float, in m

3.3.2 Wave characteristics for quartering sea condition

The characteristics of the encountered equivalent static wave to consider in quartering sea condition are as follows:

- sinusoïdal type
- wave length L_{WQ}, in m, resulting from the quartering wave position and defined as follow (see Fig 1):

  $$L_{WQ} = \frac{2\,L_W B_E}{\sqrt{L^2_W + B^2_E}}$$

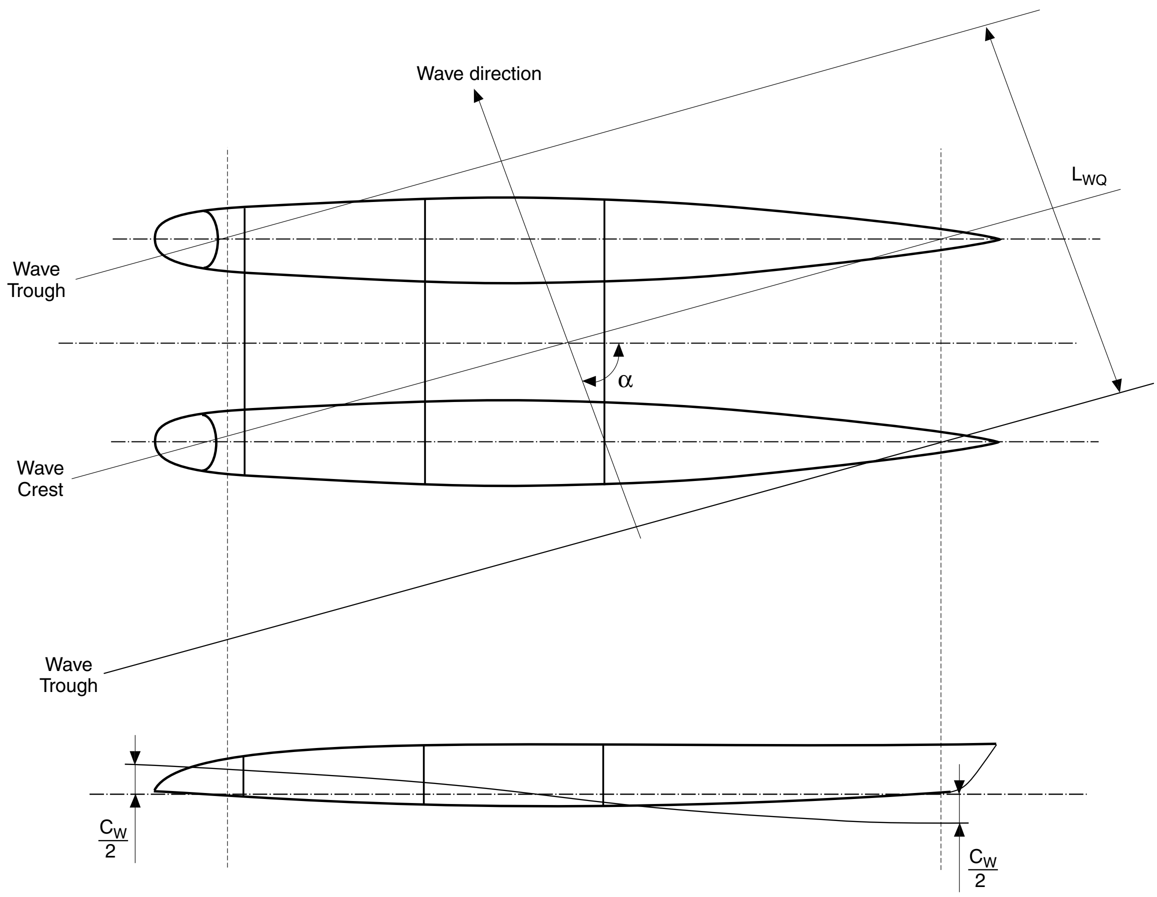
  where:

  L_W : Wave length, in m, as defined in Ch 1, Sec 2, [2.2.4]

  B_E : Distance, in m, between the float axes as defined in Ch 1, Sec 2, [2.4.3]
- wave parameter, in m, equal to:

  $C_{WQ} = 0{,}625\ (118 - 0{,}36\ L_{WQ})\ L_{WQ}\ 10^{-3}$

Figure 1 : Wave torque on catamarans



3.3.3 Bending moments and shear forces

The bending moments and shear forces induced in the floats and the multihull platform by the wave torque moment M_{WT} are to be determined by a direct calculation as defined in Ch 5, Sec 4, [3.4.2] b).

4 Digging in wave loading for catamaran

4.1 Application

4.1.1 As a rule, the bending moment due to digging in wave may not be calculated and overlooked for catamaran having a front platform located at a distance from the forward end of floats less than 5% of L_{WL}.

4.2 Digging loads and distribution

4.2.1 Loads

The linear loads, in kN/m, applied to the fore part of the floats corresponding to the digging in wave conditions defined in Ch 4, Sec 1, [2.3.2] are calculated as follow (see Fig 2):

- For the float the more sunk in the wave:

$$F_{vm} = \frac{8F'}{3L_W}$$

$$F_{hm} = \frac{8F''}{3L_W}$$

- For the float the less sunk in the wave:

$$F_{vl} = \frac{4F'}{3L_W}$$

$$F_{hl} = \frac{4F''}{3L_W}$$

where:

F' : vertical Archimedian overpressure force, in KN, equal to:

$$F' = \frac{1,8g\Delta d\sin 10^{\circ}}{\delta_1 + \delta_2} \cdot n$$

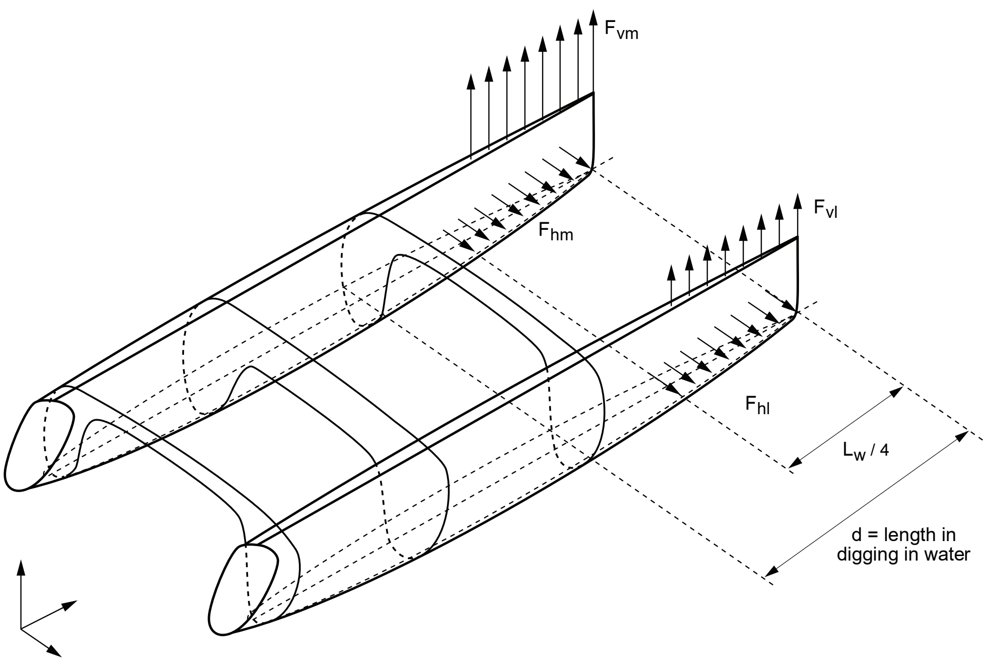
F'' : horizontal Archimedian overpressure force, in KN, equal to: F'' = F' cos 80°

L_W : L_W = 0,5 (L_{WL} + L_{HULL})

g : Gravity acceleration taken equal to 9,81 m/s

Δ : Full load displacement, in T, of the catamaran

Figure 2 : Digging loads and distribution



d : Length, in m, of digging in water, equal to the distance between the extreme fore end of each float and the forward part of the platform

δ_1, δ_2 : Vertical height of the digging in wave, in m, of a point located at d/2 abaft fore end of each float calculated as follow:

$$\delta_1 = \frac{1}{3} \cdot L_W \cdot \tan 10^\circ$$

$$\delta_2 = \frac{1}{6} \cdot L_W \cdot \tan 16^\circ$$

4.2.2 Bending moment and shear force

The bending moments and shear forces induced in the floats and the multihull platform by the digging in wave loading case are to be determined by a direct calculation as defined in Ch 5, Sec 4, [3.4.2] c).

Note 1: For non conventional location of the fore part of the multihull platform, the Society may decide to consider another load distribution, on a case by case basis.

5 Rig loads for monohull and catamaran

5.1 Sailing monohull with one mast

5.1.1 The maximum hull girder bending moment M_{RIG}, in kN.m, induced by the standing rigging is to be not less than the greater value of M_{RIGF} and M_{RIGA}, where, according to Fig 3:

M_{RIGF} : The greater value of:

- where only the forestay is loaded: $M_{RIGF} = F_E \sin \alpha_E L_E$
- where only the baby stay is loaded: $M_{RIGF} = F_{BE} \sin \alpha_{BE} L_{BE}$
- where both the forestay and the baby stay are loaded simultaneously: $M_{RIGF} = F_E \sin \alpha_E L_E + F_{BE} \sin \alpha_{BE} L_{BE}$

$M_{RIGA} = M_P + M_{V1} + M_{D1}$

with:

- $M_P = F_P \sin \alpha_P L_P$
- $M_{V1} = F_{V1} L_{V1}$
- $M_{D1} = F_{D1} \sin \alpha_{D1} L_{D1}$

F_P : Sum of design forces applied on backstay and mainsheet, in kN, to be applied at backstay chain plate

F_{V1} : Design force on vertical shroud, in kN

F_{D1} : Design force on lower shroud, in kN

F_E : Design force on forestay, in kN

F_{BE} : Design force on baby stay, in kN

α_i : Angle measured between the horizontal and the considered shroud, in degree

L_i : Horizontal distance between the mast foot and the considered shroud chainplate, in m.

5.1.2 The maximum hull girder vertical shear force Q_{RIG}, in kN, induced by the standing rigging is to be not less than the greater value of Q_{RIGF} and Q_{RIGA}, where, according to Fig 3:

Q_{RIGF} : The greater value of:

- where only the forestay is loaded: $Q_{RIGF} = F_E \sin \alpha_E$
- where only the baby stay is loaded: $Q_{RIGF} = F_{BE} \sin \alpha_{BE}$
- where both the forestay and the baby stay are loaded simultaneously: $Q_{RIGF} = F_E \sin \alpha_E + F_{BE} \sin \alpha_{BE}$

$Q_{RIGA} = Q_P + Q_{V1} + Q_{D1}$

with:

- $Q_P = F_P \sin \alpha_P$
- $Q_{V1} = F_{V1}$
- $Q_{D1} = F_{D1} \sin \alpha_{D1}$

5.2 Sailing monohull with several masts

5.2.1 The hull girder bending moments M_{RIG}, in KN.m, the shear forces Q_{RIG}, in KN, and their distribution along the hull induced by the standing rigging are to be determined by a direct beam calculation as defined in Ch 5, Sec 4, [2.3.3] b).

The standing rigging loads to take into account are defined as follow, where, according to Fig 4:

F_{Vi} : Design force on vertical shroud of mast i, in KN

F_{Di} : Design force on lower shroud of mast i, in KN

F_{E1}, F_P : Respectively design force on fore stay and backstay.

Figure 3 : Rig loads designation

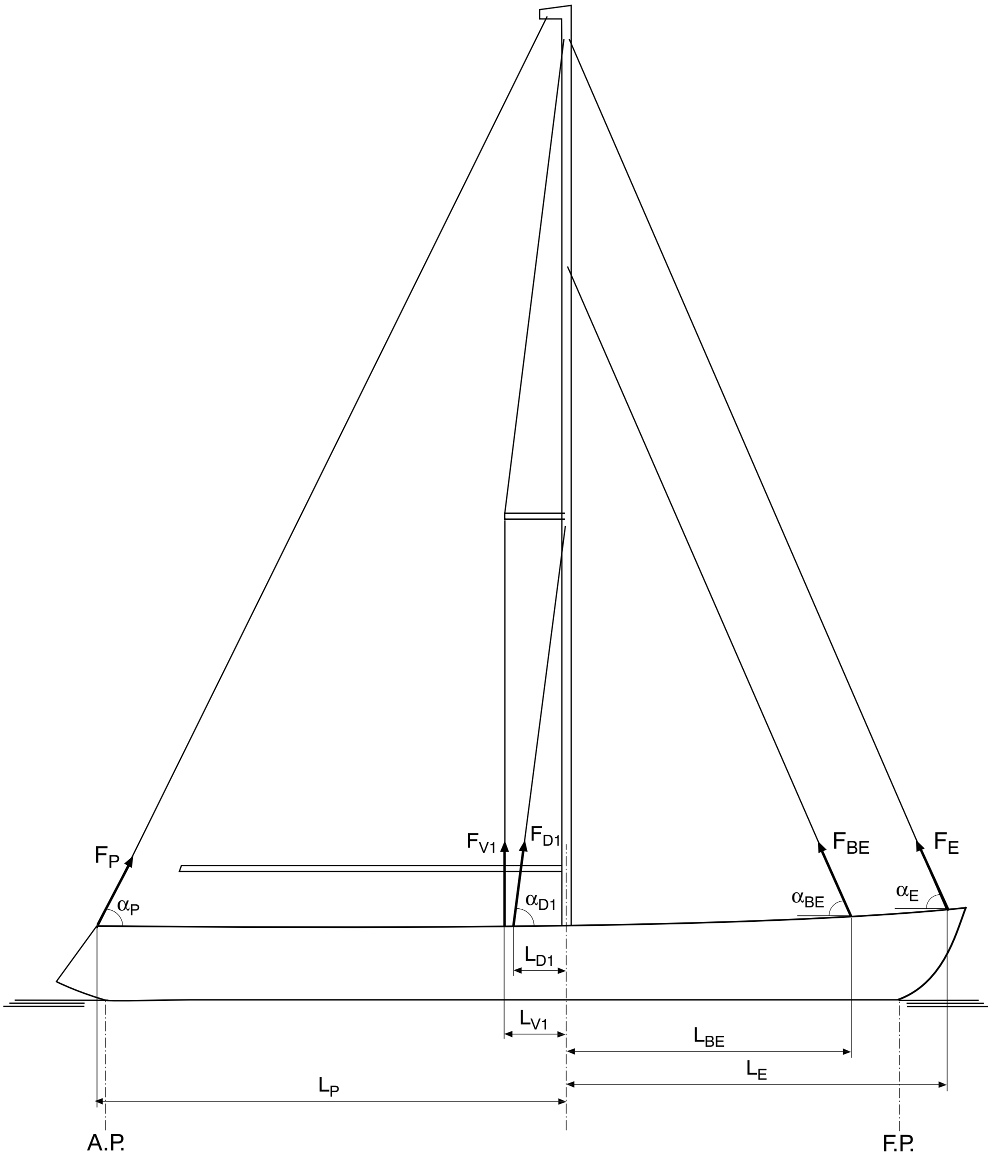
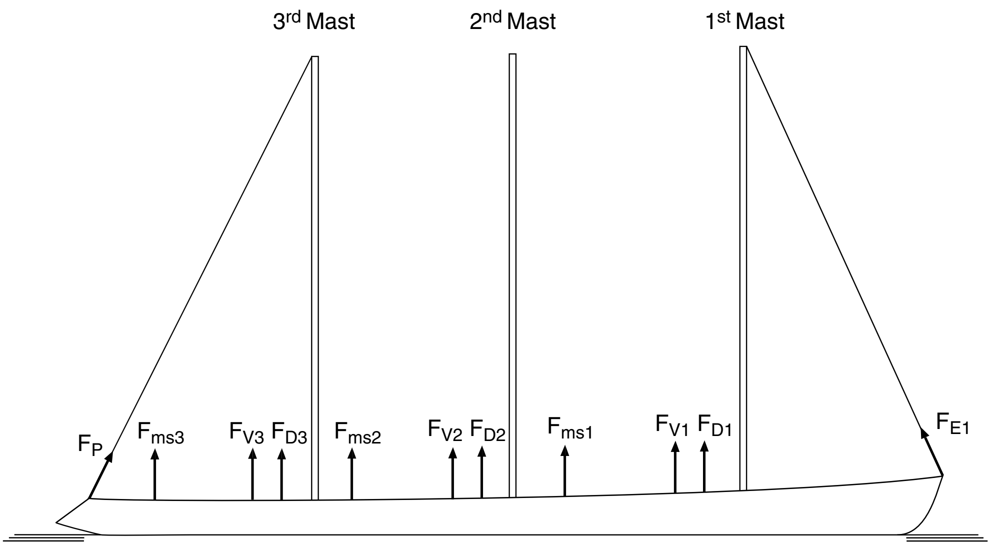


Figure 4 : Rig loads designation for sailing yachts with several masts



5.3 Sailing catamaran

5.3.1 Application

The following requirements are applicable to catamaran having one mast only, located in the longitudinal centerline axis of the catamaran.

Other arrangement are to be examined on a case by case basis.

5.3.2 Bending moments and shear forces

The bending moments M_{RIGT} and shear forces Q_{RIGT} and their distribution along the float and the transverse cross beam of the platform induced by the standing rigging are to be determined by a direct beam calculation as defined in Ch 5, Sec 4, [3.5.2] d).

The beam analysis calculation is mainly based on the torsion of the catamaran platform and is to be carried taking into account the vertical components of forces exerted by the standing rigging, where, according to Fig 5:

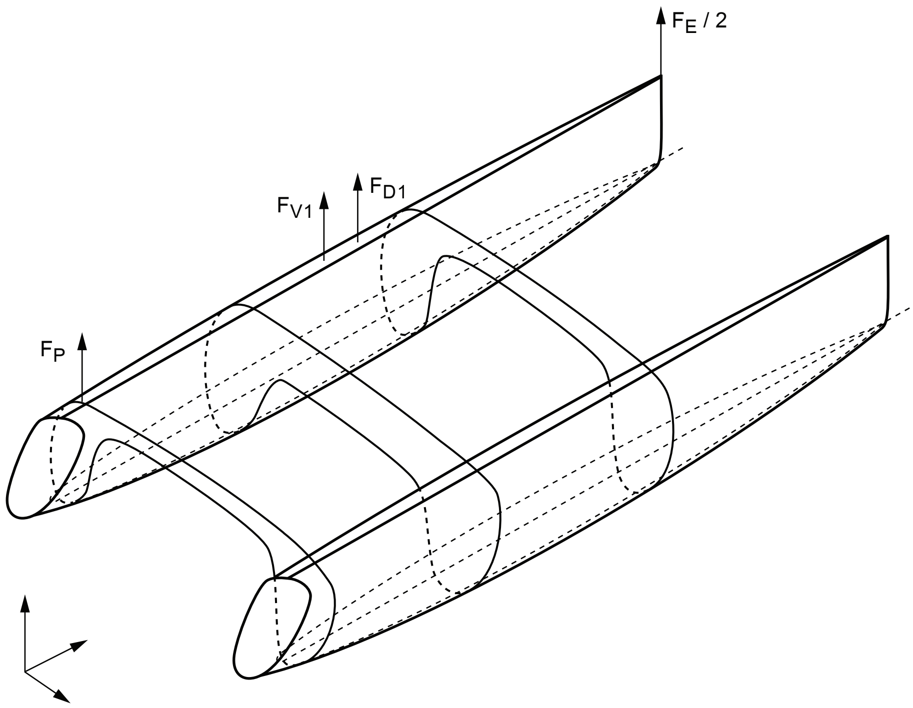
F_P : Sum of design forces applied on backstay and mainsheet, in kN, to be applied at backstay chain plate

F_{V1} : Design force on vertical shroud, in kN

F_{D1} : Design force on lower shroud, in kN

$F_E/2$: Half value of design force on forestay, in kN

Figure 5 : Standing rigging loading



Section 3 Local external Pressures on Bottom and Side Shell

Symbols

L_{WL} : Length at waterline at full load, in m, as defined in Ch 1, Sec 2, [2.2.3]
L_{HULL} : Hull length, in m, as defined in Ch 1, Sec 2, [2.2.2]
L_W : Wave length, in m, to be taken equal to: $L_W = 0,5\ (L_{WL} + L_{HULL})$
L_{WD} : Length, in m, of the platform of catamaran (see Fig 3)
Δ : Displacement, in tonnes, at full load draught T
T : Full load draught, in m, as defined in Ch 1, Sec 2, [2.6.1]
C_B : Block coefficient defined in Ch 1, Sec 2, [2.7.1]
n : Coefficient depending on the navigation notation, as given in Ch 4, Sec 1, [4]
Base Line: As a rule, the base line BL is a fictive line located at the lower point of the hull bottom where z = 0 (see Fig 1)
z : Z co-ordinate, in m, at the calculation point according to Fig 1
ρ : Sea water density, taken equal to 1,025 t/m^2
g : Gravity acceleration taken equal to 9,81 m/s^2
V : Maximum ahead service speed, in knots.

1 Definition and application

1.1 General

1.1.1 The structure of the bottom and the side shell of yachts are to be checked taking into account the external wave loads and the external dynamic loads defined in the present Section.

1.1.2 Definitions

The local external pressures to be considered are:

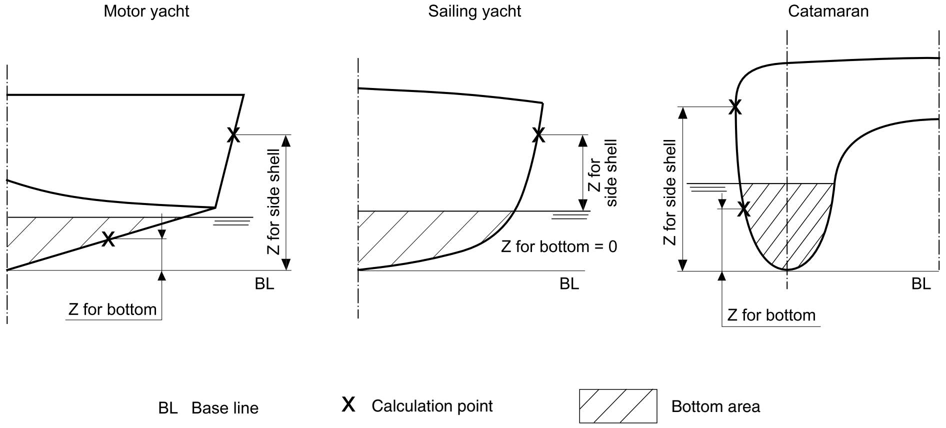
a) Sea pressure: Still water loads (due to hydrostatic external sea pressure in still water), and wave loads (due to wave pressure and ship motions).

b) Dynamic sea pressures: The dynamic sea pressures are loads which have a duration shorter than the period of wave loads and are constituted by:
   - side shell impacts and, for multihull, platform bottom impact: tm98o be calculated for the plating and the secondary stiffeners only
   - bottom slamming pressure: to be calculated for the structural elements of the bottom of planing hull motor yacht as defined in Ch 1, Sec 2, [2.11] where slamming may occur, and for monohull sailing yacht.

1.1.3 Bottom area

The bottom area is the part of the hull located below the full load waterline.

Figure 1 : Vertical distance z for monohull motor yacht, monohull sailing yacht and catamaran motor or sailing yacht



1.1.4 Side shell area

The side shell area is the part of the hull located above the full load waterline.

2 Sea pressures on bottom and side shell

2.1 Sea pressures calculation

2.1.1 The sea pressures on bottom and side shell are to be taken into account for the platings, secondary stiffeners and primary stiffeners scantling of all type of yacht.

2.1.2 The wave loads values, in kN/m², in the different areas of the hull defined in Fig 2, are to be calculated by the following formula:

$$P_S = \rho g\left[T + \left(\frac{nC_{Wl}}{X_I} + h_2\right) - z\right] \geq P_{dmin}$$

where:

C_{Wl} : Wave parameter, in m, to be taken equal to:

- $C_{Wl} = 10 \log (L_W) - 10$ for $L_W \geq 25$ m
- $C_{Wl} = 1{,}45\ e^{0{,}04\ Lw}$ for $L_W < 25$ m

X_i : Wave load coefficient, defined in Tab 1, in relation to the area considered shown on Fig 2

h_2 : Parameter, in m, equal to:

- for monohull: $h_2 = 0$
- for catamaran:
  - for bottom, internal side shell and platform bottom:

$$h_2 = \frac{B_{WLi}\left(T + \frac{nC_{Wl}}{X_I}\right)C_B}{B_E - B_{WLi}}$$

  - for external side shell:

    $h_2 = 0$

where:

B_{WLi} : Waterline breadth of one float, in m, at full load waterline measured at the middle of the area X_i considered

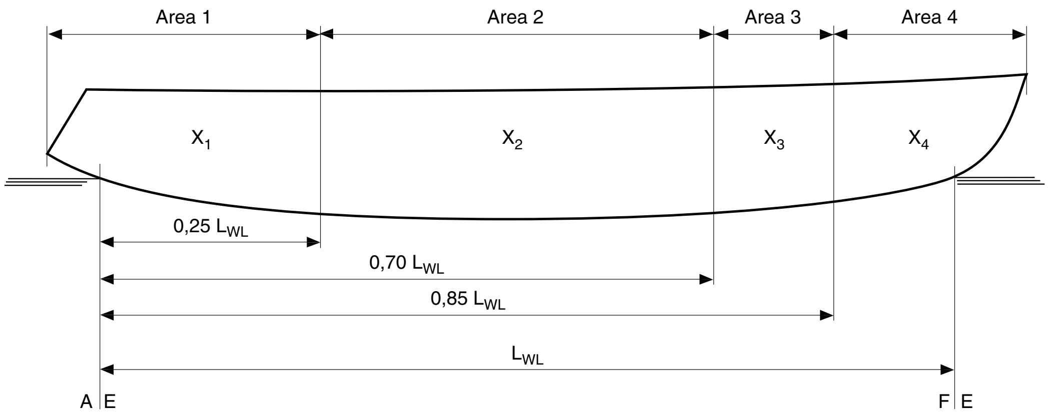
B_E : Breadth, in m, between float axis as defined in Ch 1, Sec 2, [2.4.3].

P_{dmin} : Minimum sea pressure on exposed deck, in KN/m², on the considered area, as defined in Ch 4, Sec 4, [1.1.2] .

Table 1 : Wave load coefficients X_i

Type of yachts	Area 1 X_1	Area 2 X_2	Area 3 X_3	Area 4 X_4
Monohull motor yacht	2,7	2,7	2,0	1,70
Monohull sailing yacht	2,0	2,0	1,75	1,35
Multihull motor yacht	2,45	2,45	1,8	1,4
Multihull sailing yacht	2,4	2,4	1,6	1,2

Figure 2 : Load areas and coefficient Xi for the external side shell and bottom sea pressure



3 Dynamic loads

3.1 Side shell and platform bottom impacts

3.1.1 General

The side shell impact and the platform bottom impact (for multihull) represent the local wave impact acting on the hull, independently of the ship motion.

These impacts are considered as locally distributed like a water column of 0,6 m diameter and is to be applied above the minimum draught operational for:

- the side shell and bulwarks: on all the length of the ship
- the lowest tier of side walls of superstructure, where the side wall is in the prolongation of the side shell.

The side shell impact and platform bottom impact (for multihull) may be disregarded for ships having the notation **sheltered water**.

3.1.2 Impact calculation on side shell

The impact pressure p_{ssmin}, in kN/m^2, acting on the side shell is not to be less than:

$p_{ssmin} = C_i \, n_1$

where:

C_i : Dynamic load, in kN/m^2 defined in Tab 2

n_1 : Coefficient to be taken equal to:

- 1 for **unrestricted navigation** or **navigation limited to 60 nautical miles**
- 0,7 for **coastal area**.

3.1.3 Impact calculation on internal side shell and platform bottom of multihull

The impact pressure p_{ssmin}, in kN/m^2, acting on the internal side shell and on the platform bottom of multihull is not to be less than:

$p_{ssmin} = C_i \, n_1$

where:

C_i : Dynamic load, in kN/m^2 defined in Tab 3

n_1 : Coefficient defined in [3.1.2].

When the platform of multihull is extended up to the fore float, the fore area 6 is to be considered as area 7 (see Fig 3).

3.2 Bottom slamming pressures

3.2.1 General

Slamming phenomenon on bottom area, induced by heave and pitch accelerations is to be considered for planing hull motor yacht as defined in Ch 1, Sec 2, [2.11], where slamming may occur, and for monohull sailing yacht

As a rule, bottom slamming loads are to be calculated for the following areas:

- for planning hull motor yacht of monohull type:

  on bottom area, up to the limit of bilges or hard chines, and from the transom to the fore end
- for planning hull motor yacht of multihull type:

  on bottom area of each float, up to the limit of bilges or hard chines, and from the transom to the fore end
- for sailing yacht of monohull type:

  on bottom area, up to the waterline at sides, and from a transverse section located at the centre of gravity of the keel or the bulb keel to the fore end.

For the present Subarticle, the bottom area is to be considered as the part of the bottom located between the center line of the hull or the float and the chine defined in Ch 1, Sec 2, [2.8].

Note 1: As a general rule, due to the rounded bottom shape of floats of catamaran sailing yacht, it is not necessary to calculate bottom slamming loads on these areas.

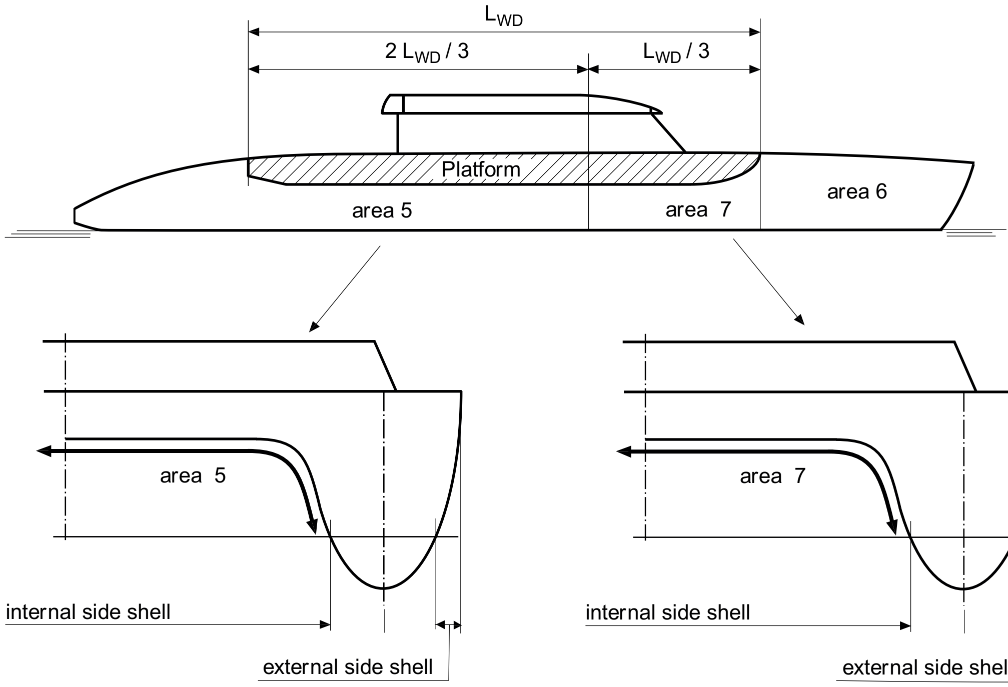
Table 2 : Dynamic load C_i on side shell

	from T to T+1, in m	from T+1 to T+3, in m	above T+3, in m
from aft part to 0,70 L_{WL}	55	40	30
from 0,70 L_{WL} to fore part	70	55	30

Table 3 : Dynamic load C_i on internal side shell and platform bottom of multihull

Areas (see Fig 3)	from T to T+1, in m	from T+1 to T+3, in m	above T+3, in m
Area 5	55	40	30
Area 6	70	55	30
Area 7	80	70	50

Figure 3 : Load areas for impact pressure on multihull



3.2.2 Bottom slamming pressures

a) Bottom slamming pressures for planing hull motor yacht:

The slamming pressure p_{sl}, in kN/m², considered as acting on the bottom of hull in planning hull mode is to be not less than:

$P_{sl} = P_{sl1} K_2$

where:

K_2 : Area factors defined in [3.2.3] b)

P_{sl1} : Design bottom slamming pressure, in kN/m², equal to:

$$p_{sl1} = 70 \cdot \frac{\Delta}{S_r} \cdot K_1 \cdot K_3 \cdot a_{CG}$$

K_1 : Distribution factor defined in [3.2.3] a)

K_3 : Bottom shape factors defined in [3.2.3] c)

a_{CG} : Design vertical acceleration at L_{CG}, defined in [4.1].

b) Bottom slamming pressures for monohull sailing yachts:

The slamming pressure p_{sl}, in kN/m², considered as acting on the bottom of monohull sailing yacht from the position of the center of gravity of the keel to the fore end, is to be not less than:

$P_{sl} = P_{sl1} K_2$

where:

K_2 : Area factors defined in [3.2.3] b)

P_{sl1} : Design bottom slamming pressure, in kN/m², equal to:

$$p_{sl1} = 70 \cdot \frac{\Delta}{S_r} \cdot K_3 \cdot a_v$$

K_3 : Bottom shape factors defined in [3.2.3] c)

a_v : Total vertical acceleration resulting from the sum of heave and pitch accelerations as defined in [4.2].

3.2.3 Dynamic load factors K_i

The dynamic load factors K_i are to be calculated as follows:

a) Distribution factor K_1:

The longitudinal slamming pressure distribution factor K_1 for the calculation of the design bottom slamming pressure in planing hull mode is defined in Tab 4.

b) Area factor K_2:

The area factor K_2 is a coefficient taking into account the dimension and the material of the structure element submitted to bottom slamming load. This factor is defined by the following formula:

$$K_2 = 0,455 - 0,35\frac{u^{0,75} - 1,7}{u^{0,75} + 1,7} \geq K_{2min}$$

where:

$$u = 100\frac{s_a}{S_r}$$

s_a : Area, in m^2, supported by the element (plating, stiffener, floor or bottom girder)

For plating, the supported area is the spacing between the stiffeners multiplied by their span (the span is not to be taken more than three times the spacing between the stiffeners)

S_r : Reference area, in m^2, equal to:

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

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

K_{2min} : Minimum values of K_2, taken equal to:

- for steel, aluminium and HDPE structure:

  K_{2min} = 0,50 for plating

  K_{2min} = 0,45 for secondary stiffeners

  K_{2min} = 0,35 for primary stiffeners

- for composite and plywood structure:

  K_{2min} = 0,15 for plating and for secondary stiffeners

  K_{2min} = 0,35 for primary stiffeners.

c) Bottom shape factor K_3:

The bottom shape and deadrise factor K_3 is defined by the following formula:

$$K_3 = (50 - \alpha_d)/(50 - \alpha_{dCG}) \leq 1$$

where:

α_{dCG} : Deadrise angle, in degrees, measured at ship's longitudinal centre of gravity L_{CG}, as shown on Fig 4

α_d : Deadrise angle at the considered transversal section, in degrees, measured as shown on Fig 4

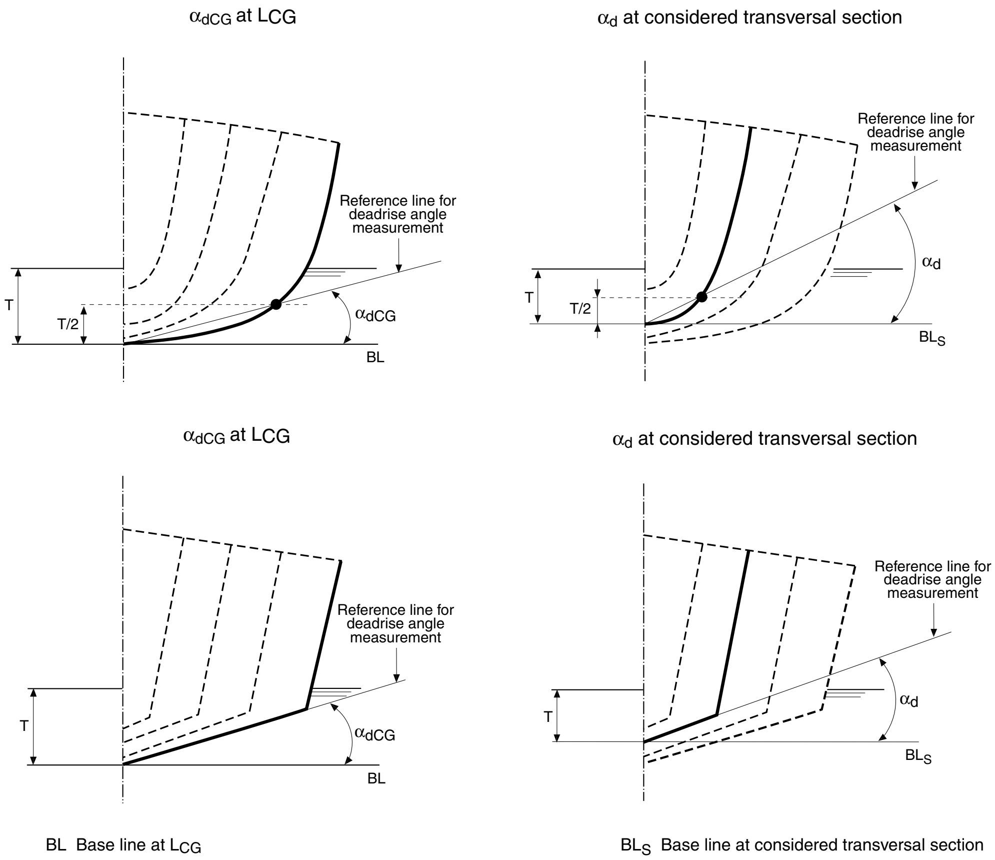
Values taken for α_d and α_{dCG} are to be within the following boundary:

- For sailing yacht: 10° and 30°
- For motor yacht: 10° and 50°.

Table 4 : Distribution factor K_1

Location	K_1
from aft part to 0,25 L_{WL}	0,60
from 0,25 L_{WL} to 0,70 L_{WL}	0,90
from 0,70 L_{WL} to 0,85 L_{WL}	1,00
from 0,85 L_{WL} to fore part	0,75

Figure 4 : Deadrise angle



4 Design vertical accelerations

4.1 Design vertical acceleration for planing hull motor yacht

4.1.1 General

The requirements of this Article apply to planing hull motor yacht:

- for which $V \geq 7,16\ \Delta^{1/6}$
- featuring planning hull mode to reach the contractual speed.

It is the designer responsibility to specify the range of speeds where the motor yacht operates in planning hull mode.

Motor yachts for which $V \geq 10\ L_{WL}^{0,5}$ shall be individually considered by the Society.

4.1.2 Design vertical acceleration a_{CG} at L_{CG}

a) Design vertical acceleration

The design vertical acceleration a_{CG} calculated at L_{CG} is to be defined by the Designer and is to correspond to the highest accelerations deduced by the relationship between instantaneous ship speeds associated to wave heights encountered at the different considered speeds.

The design vertical acceleration a_{CG} is to be considered as a relative acceleration, expressed in g, in addition to the gravity acceleration.

b) Range of speed:

It is the Designer responsibility to specify the range of speeds where the ship is in planing hull mode and to define a relation between the speed and the height of the wave that provides a maximum vertical acceleration less than the design value considered for the hull structure review. This relation may be determined on the basis of the results of model tests or full-scale measurements.

c) Vertical acceleration specification

The value of the vertical acceleration at L_{CG} is a basis for the structure scantling review within the scope of classification. The value of the maximum vertical acceleration a_{CG}, expressed in g, considered for the structure review is to be specified on the midship section drawing.

4.1.3 Information in relation to the design vertical acceleration

a) Information for vertical acceleration

For information only, when the Designer value of the vertical acceleration is not available, the following value of a_{CG}, expressed in g, may be used taking into account the type of design and the sea conditions:

$$a_{CG} = foc \cdot soc \frac{V}{\sqrt{L_{WL}}} \leq a_{CGmax}$$

where:

foc, soc : Values given, respectively, in Tab 5 and Tab 6.

a_{CGmax} : Maximum value of the vertical acceleration, in g, as defined in Tab 7

b) Information about relation between instantaneous speeds and associated wave heights

For information only, where the relation between the speeds and the associated wave heights is not defined by the Designer, the following formula may be used between instantaneous speeds V_x and associated wave heights H_S in planing hull mode compatible with the design acceleration considered for the hull structure check:

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

where:

H_S : Associated wave height, in m, to the considered speed V_x

a_{CG} : Design vertical acceleration, in g, considered for the structure scantling review

V_x : Speed considered, in knots

α_{dCG} : Deadrise angle, in deg, at L_{CG}. In this formula, α_{dCG} is to be taken between 10° and 30°

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

B_W : Maximum breadth at full load waterline. For catamarans, B_W is to be taken as the sum of the breadth of each hull

K_{FR}, K_{HS} : Coefficients defined as follows:

- for planing hull for which $V/L^{0,5} \geq 3$ and $\Delta/(0,01L)^3 \geq 3500$:

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

  $K_{HS} = 1$

- for planing hull for which $V/L^{0,5} < 3$ or $\Delta/(0,01L)^3 < 3500$:

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

  $K_{HS} = H_S / T$

The formula of H_S is only valid if all the following relationships are simultaneously complied with:

- $3500 < \Delta / (0,01\ L_{WL})^3 < 8700$
- $3 < L_{WL} / B_W < 5$
- $10° < \alpha_{dCG} < 30°$
- $0,2 < H_S / B_W < 0,7$
- $3,0 < V / (L_{WL})^{0,5} < 10,9$

Note 1: This relation between the speeds and the associated wave heights is not to be considered as an operational envelope. It is the crew's responsibility to operate in a proper manner and to suitably reduce the speed according to the environmental significant wave height with respect to the rules loadings on which classification is based.

Table 5 : Values of foc

Type of design **(1)**	Cruise motor yacht	Sport motor yacht	Offshore racing motor yacht **(2)**	Motor yacht with specific equipment
foc	0,666	1,000	1,333	1,666

(1) The type of yacht design is to be defined by the Designer, based on the following assumption at maximum speed in service:
- Cruise Motor yacht:
  The hull is mainly intended to be sustained by a combination of buoyancy and planning effect
- Sport Motor yacht:
  The hull may be submitted during short moments to only planning effect
- Offshore racing Motor yacht:
  The hull is consistently submitted to planning effect
- Motor yacht with specific equipment:
  The yacht is submitted to the same effect as Offshore racing Motor yacht and is fitted with safety arrangement (for example safety belts).

(2) This value is given for information only, racing yachts not being covered by the present Rules (see Pt A, Ch 1, Sec 1, [1.1.6]).

Table 6 : Values of Soc

Navigation notation	**unrestricted navigation**	**navigation limited to 60 nautical miles**	**coastal area**	**sheltered area**
Wave height (for information only) **(1)**	$H_s \geq 4{,}0$ m or $2{,}5 \text{ m} \leq H_s < 4{,}0$ m		$0{,}5 \text{ m} < H_s < 2{,}5$ m	$H_s \leq 0{,}5$ m
soc	C_F **(2)**	0,30	0,23	0,14

(1) Wave heights, given for information only, in relation with the navigation notations are wave heights which are exceeded for an average of not more than 10% of the year.

(2) $C_F = 0,2 + \dfrac{0,6}{V/\sqrt{L_{WL}}} \geq 0,32$

Table 7 : Maximum values of a_{CG} for motor yacht

Type of design **(1)**	Limit value of a_{CG}, in g
Cruise motor yacht	1,0
Sport motor yacht	1,5
Offshore racing motor yacht	2,0
Motor yacht with specific equipment (e.g. safety belts)	2,5

(1) See the type of design classification in Tab 5

4.1.4 Vertical acceleration in relation to the ship location areas

The vertical acceleration a_z, in m/s², to be taken into account for hull in planing mode is to be taken equal to the following value:

$a_z = g\ a_V$

where:

$a_V = K_V\ a_{CG}$

with:

K_V : As defined in Tab 8

a_{CG} : Design vertical acceleration at L_{CG} as defined in [4.1.2]

Table 8 : Value of K_V

Location	K_V
from aft part to 0,25 L_{WL}	1,00
from 0,25 L_{WL} to 0,70 L_{WL}	1,20
from 0,70 L_{WL} to 0,85 L_{WL}	1,55
from 0,85 L_{WL} to fore part	1,85

4.2 Design vertical acceleration for monohull sailing yacht

4.2.1 The vertical design acceleration a_V, express in g, for monohull sailing yacht is calculated on the basis of the combination of heave and pitch accelerations.

4.2.2 Heave acceleration

The heave design vertical acceleration a_H, in g, may be calculated as follows:

$a_H = 2{,}7\ foc \cdot Soc$

where foc and Soc are defined in Tab 9 and Tab 10.

4.2.3 Pitch acceleration

The pitch design vertical acceleration a_P, expressed in g, in a transversal section, may be determined as follows:

- For $x < x_k$: $a_p = 0$
- For x located in the area 2: $a_p = 0{,}23.a_{PFP}$
- For x located in the area 3: $a_p = 0{,}57.a_{PFP}$
- For x located in the area 4: $a_p = 0{,}85.a_{PFP}$

where:

x_K : Distance, in m, from the aft end (AE) and the centre of gravity of the keel

x : Distance, in m, of the considered transversal section from the aft end (AE)

a_{PFP} : Pitch vertical acceleration, expressed in g, at fore end (FE) to be taken equal to:

- 3 a_H for race sailing yacht (value given for information only, racing yachts not being covered by these Rules, see Pt A, Ch 1, Sec 1, [1.1.6])
- 2,1 a_H for bulb keel sailing yacht
- 1,5 a_H for sailing yacht with bar keel
- a_H for lifting keel yachts

a_H : Heave acceleration, in g, calculated according to [4.2.2].

4.2.4 Total design acceleration for slamming pressure

The total design vertical acceleration a_v, expressed in g, to be considered for the calculation of the slamming pressure in each transverse section considered is to be taken equal to:

$a_V = a_H + a_p$

where:

a_H : Heave acceleration as defined in [4.2.2]

a_p : Pitch acceleration as defined in [4.2.3].

4.2.5 Vertical acceleration in relation to the ship location areas

The vertical acceleration a_z, in m/s², to be taken into account in relation to the ship location for monohull sailing yacht is to be taken equal to the following value:

$a_z = g\ a_V$

with:

a_V : Total design acceleration as defined in [4.2.4].

Table 9 : Values of foc

Type of design	Cruise sailing yacht	Sport sailing yacht	Race sailing yacht **(1)**
foc	0,666	1,000	1,333
(1) This value is given for information only, racing yachts not being covered by these Rules (see Pt A, Ch 1, Sec 1, [1.1.6]).			

Table 10 : Values of soc

Navigation notation	**Unrestricted navigation**	**Navigation limited to 60 nautical miles**	**Coastal area**	**Sheltered area**
Wave height (for information only) **(1)**	$H_s \geq 4{,}0$ m or $2{,}5$ m $\leq H_s < 4{,}0$ m		$0{,}5$ m $< H_s < 2{,}5$ m	$H_s \leq 0{,}5$ m
soc	0,3	0,27	0,23	0,20

5 Local loads on exposed deck

5.1 General

5.1.1 The sea pressure on exposed deck is to determined as defined in Ch 4, Sec 4, [1.1].

Section 4 Loads on Decks and Local Internal and Superstructures Pressures

Symbols

L_{WL} : Full load displacement waterline length, in m, as defined in Ch 1, Sec 2, [2.2.3]

L_W : Wave length, in m, to be taken equal to: $L_W = 0,5\ (L_{WL} + L_{HULL})$

n : Navigation coefficient as defined Ch 4, Sec 1, [4]

Areas 1, 2, 3 and 4:Loads areas as defined in Ch 4, Sec 3, Fig 2

1 Local loads on decks

1.1 Exposed decks

1.1.1 Sea pressure

The sea pressure on any point of exposed deck, in kN/m², is to be determined as follow:

$$P_s = (p_0 - 10 z_D)\varphi_1\varphi_2\varphi_3 \geq P_{dmin}$$

where:

p_0 : Sea bottom pressure P_S in the considered area, in kN/m², calculated at the base line according to Ch 4, Sec 3, [2.1.2] with z = 0

z_D : Vertical distance, in m, between the deck at side at the considered transverse section and:
- the full load waterline for sailing yacht monohull
- the baseline for other type of yacht

φ_1 : Coefficient for pressure on exposed deck, equal to:
- for the freeboard deck(m), as defined in Ch 2, Sec 2, [2.2.1]:
  $\varphi_1 = 1,00$
- for the first deck above the freeboard deck(m):
  $\varphi_1 = 0,75$
- for the second deck above the freeboard deck(m):
  $\varphi_1 = 0,56$
- for the third deck above the freeboard deck(m):
  $\varphi_1 = 0,42$
- for the decks above:
  $\varphi_1 = 0,32$

φ_2 : Coefficient taken equal to:

$$\varphi_2 = \frac{L_{WL}}{120} \geq 0,42$$

φ_3 : Reduction coefficient, equal to:
- when the deck is partially protected (not directly exposed to green sea effect):
  $\varphi_3 = 0,70$
- in the other case:
  $\varphi_3 = 1,00$

Note 1: A deck may be considered as partially protected when the deck is located directly behind a transversal aft wall of a superstructure or a roof. In this case, the surface of the deck to be considered as partially protected may be taken equal to 60% of the vertical aft wall superstructure or roof surface.

P_{dmin} : Minimum sea pressure on deck as defined in [1.1.2].

1.1.2 Minimum sea pressure

The minimum sea pressure P_{dmin}, in kN/m², is to be determined according the following formulae:

- in areas 1 and 2: $P_{dmin} = 17,5\ n\ \varphi_1\ \varphi_2\ \varphi_3 \geq 5$
- in areas 3 and 4: $P_{dmin} = 19,6\ n\ \varphi_1\ \varphi_2\ \varphi_3 \geq 7$
- for superstructure exposed decks not directly exposed to sea pressure and not accessible to passengers or crew members: $P_{dmin} = 3$ KN/m²

where:

φ_1, φ_2, φ_3 : As defined in [1.1.1].

1.2 Accommodation decks

1.2.1 The pressure on accommodation deck in the considered area is obtained, in kN/m², from the following formula:

$$p = p_s\left(1 + \frac{a_{z\eta}}{g}\right)$$

where:

p_s : Pressure defined by the Designer, to be taken at least equal to the values given in Tab 1.

$a_{z\eta}$: Vertical acceleration, in m/s², to be taken equal to:

a) for displacement hull: $a_{z\eta} = 2,5.n$

b) for planing hull: $a_{z\eta} = 0,4.a_z \geq 2,5.n$

where:

a_z : Vertical acceleration, in m/s², as defined in Ch 4, Sec 3, [4.1.4]

c) for monohull sailing yacht: $a_{z\eta} = 0,4.a_z \geq 2,5.n$

where:

a_z : Vertical acceleration, in m/s², as defined in Ch 4, Sec 3, [4.2.5]

Table 1 : Minimum values of p_s

Accommodation deck	p_s , in kN/m²
Large public spaces	5,0
Cabins	3,0
Technical and machinery spaces	10,0
Other compartments	2,5

2 Pressure in tanks

2.1 General

2.1.1 The local internal pressure p, in kN/m², on watertight bulkheads, bottom and top of liquid capacity is to be taken equal to the greater value obtained from the following formulae:

$$p = \rho_L[a_{z\eta}(z_{TOP} - z) + g(z_L - z)]$$

$$p = \rho_L(g + a_{z\eta})(z_{TOP} - z) + 100p_{pv}$$

where:

ρ_L : Density of the liquid considered, in t/m³

$a_{z\eta}$: As defined in [1.2.1]

z_{TOP} : z co-ordinate, in m, of the highest point of the capacity (see Fig 1)

z : distance, in m, from the base line to the calculation point, as defined in:

- For steel and aluminium structure: Ch 5, Sec 5, [1.3]
- For composite, plywood and HDPE structure: Ch 6, Sec 5, [1.3]

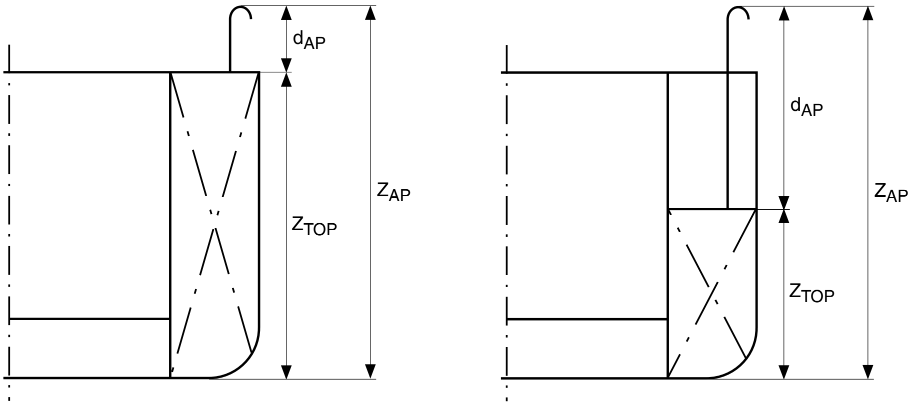
p_{pv} : Setting pressure, in bar, of safety valves, if any

z_L : $z_L = z_{TOP} + 0,5\ (z_{AP} - z_{TOP})$

with:

z_{AP} : z co-ordinate, in m, of the top of air pipe (see Fig 1).

Figure 1 : z co-ordinates



3 Testing loads

3.1 General

3.1.1 The testing loads acting on the structures subject to tank testing are obtained, in kN/m², from the formulae in Tab 2. Compartments not defined in Tab 2 are to be tested in accordance with Ch 5, Sec 11.

Table 2 : Testing loads values

Compartment or structure to be tested	Still water pressure p_{ST}, in kN/m²
Double bottom tanks, double side tanks, other deep tanks	The greater of the following: $p_{ST} = 10\ [(z_{TOP} - z) + d_{AP}]$ $p_{ST} = 10\ [(z_{TOP} - z) + 0{,}3H]$ **(1)**
Chain locker	$p_{ST} = 10\ (z_{CP} - z)$ where: z_{CP} : Z co-ordinate, in m, of the top of chain pipe
Fuel oil tanks	The greater of the following: $p_{ST} = 10\ [(z_{TOP} - z) + d_{AP}]$ $p_{ST} = 10\ [(z_{TOP} - z) + 0{,}3H]$ **(1)** $p_{ST} = 10\ [(z_{TOP} - z) + 10\ p_{PV}]$

Note 1:
z_{TOP} : Z co-ordinate, in m, of the deck forming the top of the tank excluding any hatchways.
z : Distance, in m, from the base line to the calculation point
d_{AP} : Distance, in m, from the top of air pipe to the top of the compartment
p_{pv} : Setting pressure, in bar, of the safety relief valves, where relevant.
(1) 0,3H is not to be taken less than 0,9 m nor greater than 2,4 m, where H is the height of the tank, in m. For yachts greater than 40 m, 0,3H is to be taken equal to 2,4 m.

4 Flooding loads

4.1 General

4.1.1 The internal pressure p_{fl} to be considered on watertight bulkheads fitted for damage stability purposes is to be obtained, in kN/m², from the following formula:

$p_{fl} = 1{,}6\ \rho\ g\ n\ d_f$ with $p_{fl} \geq 0{,}8\ g\ d_0$

where:

d_f : Distance, in m, from the calculation point to the bulkhead deck (or freeboard deck[(m)] when there is no bulkhead deck). Where the results of damage stability calculations are available, the deepest equilibrium waterline may be considered in lieu of the bulkhead deck

d_0 : Height, in m, to be taken equal to:

$d_0 = 1$ if $L_{WL} \leq 50$ m

$d_0 = 0{,}02\ L_{WL}$ if $L_{WL} > 50$ m

5 Local loads on superstructures

5.1 General

5.1.1 Standard height of superstructure

As a rule, the standard height of a superstructure is taken equal to 1,8m.

5.1.2 Tiers of superstructures and deckhouses

Where the distance between the full load waterline and the freeboard deck(m) exceeds one standard superstructure height as defined in [5.1.1], the lowest tier may be considered as a second tier when calculated the superstructure and deckhouses loads, excepted for the unprotected front walls.

For monohull sailing yacht, the distance between the waterline and the freeboard deck(m) is to be measured taking into account the maximum angle of heel of the yacht to be taken not lesser than 30°.

5.1.3 Definition of tiers

The lowest tier is the tier which is directly situated above the Free Board deck(m).

The second tier is that located immediately above the lowest tier, and so on.

5.2 Sea pressure on superstructure decks

5.2.1 The sea pressure on superstructure decks exposed to green seas is to be determined according to [1].

5.3 Sea pressure on superstructure walls

5.3.1 The lateral pressure of the exposed walls of superstructures and deckhouses, in kN/m², is to be determined as follow:

$$p_S = 7acn(bf - z_S) \geq P_{sumin}$$

where:

a : Coefficient given in Tab 3

c : Coefficient equal to:

- for monohull motor yacht: $c = 0{,}3 + 0{,}7\ b_1/B_{ed}$
- for monohull sailing yacht: c = 1,0
- for catamarans (sailing or motor): c = 0,5

b : Coefficient equal to:

- in areas 1 and 2: b = 1,0
- in areas 3 and 4: b = 1,5

B_{ed} : Actual maximum moulded breadth of ship on the exposed weather deck, in m, at the considered transversal section

b_1 : Moulded breadth of superstructure or deckhouse, in m, at the considered transversal section.

f : Coefficient equal to: $f = 0{,}076\ L_{WL} - 0{,}6$

z_S : Vertical distance, in m, between the full load waterline and the calculation point, located as follows:

- for plating: mid-height of the elementary plate panel
- for stiffeners: mid-span

P_{sumin} : Minimum sea pressure, in KN/m², as defined in Tab 4.

5.3.2 When the front wall is sloped aft, the front wall pressures values P_S and P_{sumin} may be reduced by the value of the cosine of the angle α, where α is defined in Fig 2.

The value of the cosine of the angle α is not to be taken smaller than 0,5.

5.3.3 Lowest tier of sidewalls in the prolongation of the side shell

Impact loads on side shell as defined in Ch 4, Sec 3, [3.1.2] are also to be considered for the exposed lowest tier of sidewalls of superstructures in the prolongation of the side shell or shifted from the side wall of less than 300 mm when not protected by a bulwark.

Figure 2 : angle of superstructures

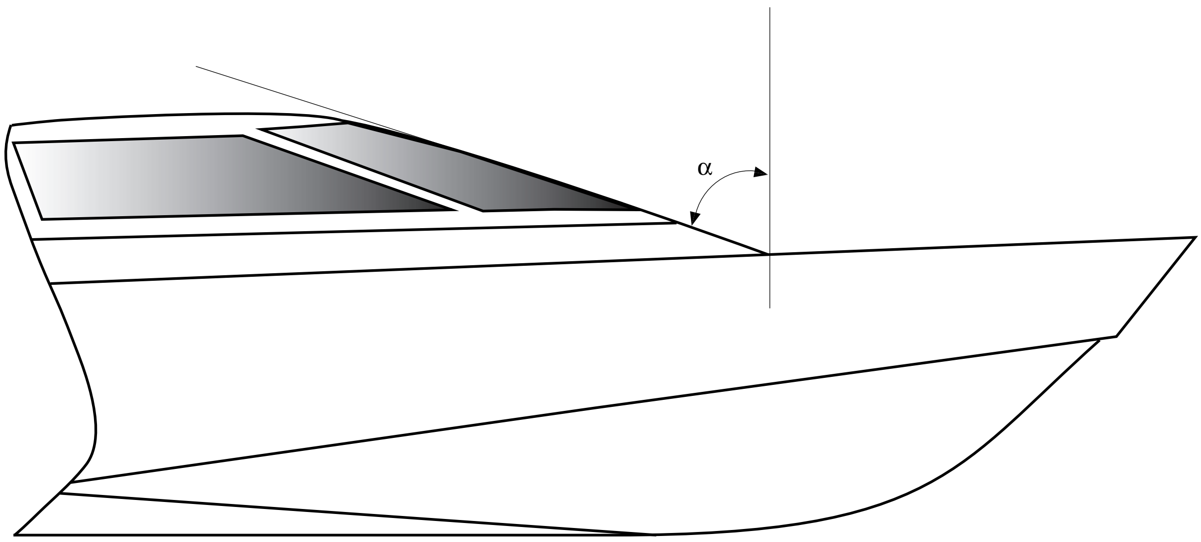


Table 3 : Coefficient a

Location		a
Unprotected Front wall	First tier	$2,0 + L_{WL}/ 120$
	second tier	$1,0 + L_{WL}/ 120$
	Upper tiers	$0,5 + L_{WL}/ 120$
Protected front wall	All tiers	$0,5 + L_{WL}/ 150$
Aft wall	All tiers	$0,5 + L_{WL} / 1000$
Side walls	All tiers	$0,5 + L_{WL} / 150$

Table 4 : Minimum pressures P_{sumin}

Type of wall	Location	p_{sumin} (in kN/m²)
Unprotected front wall	Lowest tier, areas 3 and 4	21 n
	Lowest tier, areas 1 and 2	15 n
	Upper tiers	10 n
Protected front wall	Lowest tier	10 n
	Second tier	7 n > 5
	Upper tiers	5
Side walls	Lowest tier, area 3 and 4	19,6 n φ_2 (see also [5.3.3])
	Lowest tier, area 1 and 2	17,6 n φ_2 (see also [5.3.3])
	Second tier	7 n > 5
	Upper tiers	5
Unprotected aft wall	Lowest tier, area 1	10 n
	Lowest tier, areas 2, 3 and 4	7 n > 5
	Upper tiers	5
Protected aft wall	Anywhere	5

Note 1:

n : Navigation coefficient as defined Ch 4, Sec 1, [4]

φ_2 : Coefficient taken equal to:

$$\varphi_2 = \frac{L_{WL}}{120} \geq 0,42$$

CHAPTER 5
STRUCTURE DESIGN AND SCANTLING REQUIREMENTS FOR STEEL AND ALUMINIUM

Section 1 General requirements and Characteristics of Materials

1 Hull scantling analysis approach

1.1 General

1.1.1 As a rule, the structure scantling is examined on the basis of the local permissible stresses defined in relation to the type of loads considered.

The structure check is to be carried out taking into account the local loads and the global loads (when considered according to Ch 4, Sec 1, [2.2.2]) independently.

When deemed necessary by the Society, the hull structure analysis taking into account the global hull girder loads and the local loads may be carried out on a case by case basis according to the methodology defined in NR600 Ships less than 90 m in length.

2 Application

2.1 General

2.1.1 The requirements of the present Chapter are applicable to yacht hulls made totally or partly of steel materials and/or aluminium alloys.

For hull or superstructure made of aluminium alloys, these requirements are to be applied together with NR561 Hull in Aluminium Alloys, specifically dedicated to ships built in aluminium within the scope of classification and/or certification, and in particular for:

- material characteristics
- principal of structural arrangement
- hull construction and survey.

2.1.2 Materials and products such as parts made of iron castings, where allowed, products made of copper and copper alloys, rivets, anchors, chain cables, cranes, masts, derrick posts, derricks, accessories and wire ropes are to comply with the applicable requirements of NR216 Materials and Welding.

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

3 Steel for hull structure

3.1 General

3.1.1 Characteristics of materials

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

3.1.2 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 practices and the applicable requirements of NR216 Materials and Welding.

3.1.3 Steel material grades and mechanical characteristics

a) Definitions:

Normal strength steels having a minimum yield strength R_{eH}=235 N/mm^2 are divided into four grades A, B, D and E. The letters A, B, D and E mean impact properties at +20°C, 0°C, •20°C and •40°C, respectively.

Higher strength steels are divided into four grades identified by the letters AH, DH, EH and FH followed by a number related to the yield strength level. The letters AH, DH, EH and FH mean impact properties at 0°C, •20°C, •40°C and •60°C, respectively.

Tab 1 gives, as a reminder, the mechanical properties of steels commonly used in the construction of ships.

Higher strength steels higher other than those indicated in Tab 1 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/mm^2 are used for a ship, the hull scantlings are to be determined considering the material factor k defined in [3.1.4].

b) Application:

Materials in the various strength members are not to be of lower grade than those corresponding to the following material classes and grades:

- General requirements:

  As defined in NR646, Ch 4, Sec 1, Tab 3 and 9. For ships less than 65 m in length, the material class and grade defined for the outside 0,4L amidships area in Table 3 is to be considered along the full length of the ship.

Note 1: Steel having a specified minimum yield stress equal to 235 N/mm^2 is denoted 'NSS'. Steel having a higher specified minimum yield stress is denoted 'HSS'.

- Ships with ice strengthening:

  As defined in NR646, Ch 4, Sec 1, Tab 8 for plates of ice strengthening area.

- Ships structures exposed to low air temperature:

  As defined in NR646, Ch 4, Sec 1 [2.4] and in Table 10 to 13. For ships less than 65 m in length, the material class and grade defined for the outside 0,4L amidships area in Table 10 is to be considered along the full length of the ship.

Table 1 : Mechanical properties of hull steels

Steel grades t ≤ 100 mm	Minimum yield stress R_{eH} , in N/mm^2	Ultimate minimum tensile strength R_m , in N/mm^2
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].		

3.1.4 Material factor k for scantling

To take into account the steel materials, a material factor k is used in the scantling formulae, as a function of the minimum specified yield stress R_{eH}.

As a rule, the scantling of the structure elements is based on a steel material having a minimum yield stress R_{eH} equal to 235 N/mm^2, corresponding to k = 1.

Unless otherwise specified, the values of material factor k are defined in Tab 2.

For intermediate values of R_{eH} , k may be obtained by linear interpolation.

Steels having a yield stress higher than 390 N/mm^2 are considered by the Society on a case-by-case basis.

For steel having a yield stress lower than 235 N/mm^2, the material factor may be taken equal to 235/R_{eH}, where R_{eH} is the minimum yield stress, in N/mm^2, of the considered material.

Table 2 : Material factor k

R_{eH} , in N/mm^2	k
235	1,00
315	0,78
355	0,72
390	0,68

3.1.5 Minimum yield stress for scantling criteria of hull structure

The minimum yield stress of steel R_y , in N/mm^2, used for the scantling criteria of the hull structure is to be taken, unless otherwise specified, equal to:

$R_y = 235 / k$

where:

k : Material factor defined in [3.1.4]

3.1.6 Through thickness properties

Where normal tensile loads induce out-of-plane stress greater than 0,5 R_y in steel plates:

- for plates with t < 15 mm, ultrasonic testing is to be performed
- for plates with t ≥ 15 mm, Z-quality steel is to be used or ultrasonic testing is to be performed,

in order to prevent laminar tearing.

The ultrasonic testing is to be performed, before and after welding, on the area of the plate located within 50 mm or t, whichever is the greater, around the weld, in accordance with NR216 Materials and Welding, Ch 3, Sec 11.

4 Aluminium alloys

4.1 General

4.1.1 Application

The characteristics of aluminium alloys to be used in the construction and their testing process are to comply with the applicable requirements of the Rule Notes:

- NR216 Rules on Materials and Welding
- NR561 Hull in Aluminium Alloys.

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

4.1.2 Minimum yield stress for scantling criteria of hull structure

The minimum yield stress of aluminium R_y , in N/mm^2, used for the scantling criteria of the hull structure is to be taken, unless otherwise specified, equal to:

$R_y = R'_{lim}$

where:

R'_{lim} : Minimum yield stress of the aluminium alloys considered, to be taken equal to the minimum value, in welded condition, between $R'_{p0,2}$ (proof stress) and 0,7 R'_m (tensile strength), where $R'_{p0,2}$ and R'_m are defined in NR561 Aluminium Ships.

4.1.3 Material factor k for scantling

To take into account the minimum yield stress of the aluminium alloy in welded condition, the material factor k used in the scantling formulae is to be taken equal to:

$k = 100 / R'_{lim}$

Section 2 Main Structure Arrangement and Other Structures

1 General

1.1 Application

1.1.1 General

The requirements of the present Section apply to longitudinally or transversely frame structure arrangements of yacht built in steel materials for:

- structural continuity of hull
- single and double bottoms
- sides and decks
- transverse and longitudinal structures
- superstructures and deckhouses.
- Special features

Any other arrangement may be considered on a case by case basis.

1.1.2 Yacht built in aluminium alloys

a) General:

Except where specified in b), the equivalent arrangements for yachts built in aluminium alloys are to be in accordance with NR561 Hull in Aluminium Alloys.

b) Sailing yacht built in aluminium alloys:

Requirements defined in [4.6] (Bottom arrangement in way of bulb keel), [5.4] (Side shell arrangement in way of chain plates) and [6.4] (Deck arrangement in way of mast) are also applicable for sailing yachts built in aluminium alloys.

2 Structural continuity of hull girder

2.1 General principles for longitudinal hull girder

2.1.1 Attention is to be paid to the structural continuity:

- in way of changes in the framing system
- at the connections of primary or ordinary stiffeners.

2.1.2 The longitudinal members contributing to the hull girder longitudinal strength are to extend continuously over a sufficient distance towards the ends of the ship.

Ordinary stiffeners contributing to the hull girder longitudinal strength are generally to be continuous when crossing primary supporting members. Otherwise, the detail of connections is considered by the Society on a case by case basis.

2.1.3 Where stress concentrations may occur in way of structural discontinuity, adequate compensation and reinforcements are to be provided.

2.1.4 Openings are to be avoided, as far as practicable, in way of highly stressed areas.

Where necessary, the shape of openings is to be specially designed to reduce the stress concentration factors.

Openings are to be well rounded with smooth edges. Generally, the radius of opening corners is to be not less than 50 mm. In way of highly stressed areas, the radius is to be taken as the greater of 50 mm and 8% of the opening width.

2.1.5 Primary supporting members are to be arranged in such a way that they ensure adequate continuity of strength. Abrupt changes in height or in cross-section are to be avoided.

2.2 General principles for cross deck of catamaran

2.2.1 Attention is to be paid to the structural continuity of the primary transverse structure of catamaran ensuring the global transversal strength of the catamaran.

The primary transverse cross structure of platform of catamaran is generally to be continuous when crossing float structures.

The general continuity principles defined in [2.1] apply also to the primary transverse cross structure of the platform.

2.3 Insert plate and doubler

2.3.1 A local increase in plating thickness is generally to be achieved through insert plates. Local doublers, normally allowed only for temporary repair, may however be accepted by the Society on a case-by-case basis.

In any case, doublers and insert plates are to be made of materials of a quality at least equal to the quality of the plates on which they are welded.

2.3.2 Doublers having a width, in mm, greater than:

- 20 times their thickness, for thicknesses equal to or less than 15 mm
- 25 times their thickness, for thicknesses greater than 15 mm

are to be fitted with slot welds, to be effected according to Ch 5, Sec 7.

2.3.3 When doublers fitted on the outer shell and strength deck within 0,6 L amidships are accepted by the Society, their width and thickness are to be such that slot welds are not necessary. Outside this area, the possibility of fitting doublers requiring slot welds will be considered by the Society on a case-by-case basis.

2.4 Connection between steel and aluminium

2.4.1 Any direct contact between steel and aluminium alloy is to be avoided.

Heterogeneous jointing system is considered by the Society on a case-by-case basis.

The use of transition joints made of aluminium/steel-clad plates or profiles is to be in accordance with NR216 Materials and Welding.

3 Local reinforcement

3.1 General principles

3.1.1 Where stress concentration may occur in way of structural discontinuities, adequate compensation and reinforcement are to be provided.

3.1.2 Reinforcements at knuckles

Knuckles are in general to be stiffened to achieve out-of-plane stiffness by fitting ordinary stiffeners or equivalent means in line with the knuckle. Arrangements without stiffener may be accepted on a case-by-case basis depending on the knuckle angle and stress level.

4 Bottom structure arrangement

4.1 General arrangement

4.1.1 The bottom structure is to be checked by the Designer to make sure that it withstands the loads resulting from the dry-docking of the yacht or the lifting by crane. These loading cases are not within the scope of classification and/or certification.

4.1.2 **Charter yacht** carrying more than 12 passengers may be considered by the Flag Administration as passenger ship. In such a case, it might be necessary to provide a continuous double bottom satisfying the relevant requirements of [4.4].

4.1.3 Provision is to be made for the free passage of water from all the areas of the bottom to the suctions, by means of scallops in floors and bottom girders.

4.1.4 Additional girder and floors may be fitted in the engine room to ensure adequate rigidity of the structure, according to the recommendations of the engine supplier.

4.1.5 If fitted, solid ballast is to be securely positioned. If necessary, intermediate girders and floors may be required. The builder is to check that solid ballast material is compatible with the hull material.

4.1.6 Where face plates of floors and girders are at the same level, the face plate of the stiffer member is generally to be continuous. Butt welds of the face plates are to provide strength continuity.

4.2 Longitudinal framing arrangement of single bottom

4.2.1 As a general rule, yachts with a longitudinally framed single bottom are to be fitted with a continuous or intercoastal centre girder welded to the floors.

4.2.2 Where side girders are fitted locally in lieu of centre girder, they are to be extended over a sufficient distance beyond the ends of the centre girder and an additional stiffening of the bottom in the centreline area may be required.

4.2.3 Centre and side bottom girders are to be extended as far as possible towards the ends of the hull.

4.2.4 Longitudinal secondary stiffeners are generally to be continuous when crossing primary members.

4.2.5 Cut-outs fitted in web of floors for crossing of bottom longitudinals are to be taken into account for the shear analysis of floors.

4.3 Transverse framing arrangement of single bottom

4.3.1 In general, the height, in m, of floors at the centreline should not be less than B/16. In the case of yachts with considerable rise of floors, this height may be required to be increased so as to ensure a satisfactory connection to the frames.

4.3.2 The ends of floors at side are to be located in line with side transverse members.

In some particular cases, it may be accepted that floor ends at side be welded on a primary longitudinal member of the side shell or the bottom.

4.3.3 Openings and cut-outs in the web of bottom girders for the crossing of floors are to be taken into account for the floor shear analysis.

4.4 Double bottom arrangement

4.4.1 Double bottom height

As a general rules, the double bottom height is to be:

- sufficient to ensure access to any part of the bottom, and
- not less than 0,7 m in way of the center girder.

4.4.2 Where the height of the double bottom varies, the variation is generally to be made gradually and over an adequate length; the knuckles of inner bottom plating are to be located in way of floors.

Where such arrangements are not possible, suitable longitudinal structures such as partial girders, longitudinal brackets etc., fitted across the knuckle, are to be fitted.

4.4.3 Adequate continuity is to be provided between double bottom area and single bottom area.

4.4.4 Floors are to be fitted:

- watertight in way of transverse watertight bulkheads
- reinforced in way of double bottom steps.

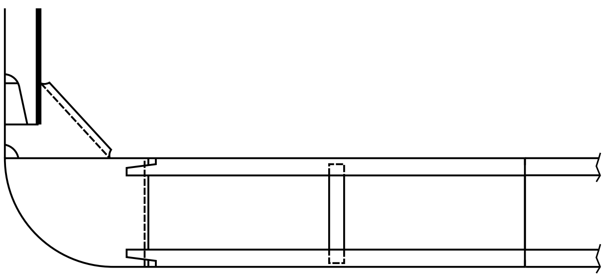
4.4.5 Watertight floors are to be fitted with stiffeners having a section modulus not less than that required for tank bulkhead vertical stiffeners.

4.4.6 In case of open floors consisting of a frame connected to the bottom plating and a reverse frame connected to the inner bottom plating, the construction principle is to be as shown on Fig 1.

4.4.7 Longitudinal secondary stiffeners

Bottom and inner bottom longitudinal secondary stiffeners are generally to be continuous through the floors.

Figure 1 : Open floor



4.5 Arrangement, scantlings and connections of bilge keels

4.5.1 Arrangement

Bilge keels may not be welded directly on the shell plating. An intermediate flat, or doubler, is required on the shell plating.

The thickness of the intermediate flat is to be equal to that of the bilge strake.

The ends of the bilge keels are to be sniped at an angle of 15° or rounded with large radius. They are to be located in way of a transverse bilge stiffener. The ends of the intermediate flat are to be sniped at an angle of 15°.

The arrangement shown in Fig 2 is recommended.

The arrangement shown in Fig 3 may also be accepted.

Figure 2 : Bilge keel arrangement

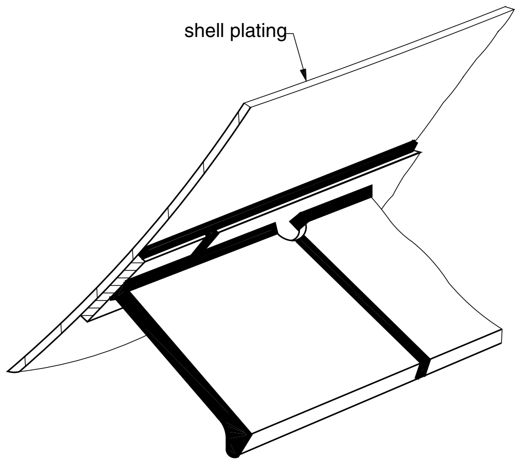
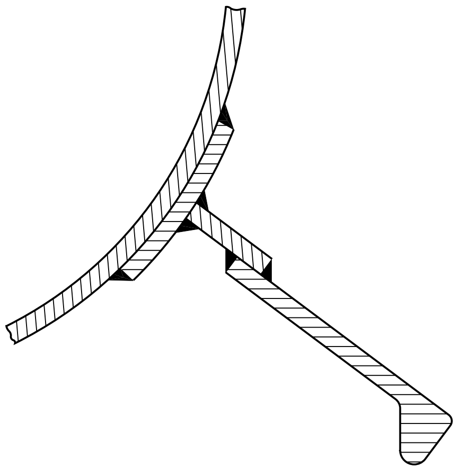


Figure 3 : Bilge keel arrangement



4.5.2 Materials

The bilge keel and the intermediate flat are to be made of steel with the same yield stress and grade as that of the bilge strake.

4.5.3 Welding

Welding of bilge keel with intermediate plate connections is to be in accordance with Ch 5, Sec 7.

4.6 Additional requirements for bottom arrangement in way of bulb keel of sailing yacht

4.6.1 The present sub-article is applicable to sailing yacht built in steel and aluminium alloys.

4.6.2 As a rule, the reinforced bottom structural members in way of the bulb keel are checked by direct calculations according to Ch 7, Sec 7.

For keel bolted to the bottom structure, bolts are to be of a high strength ant their scantling are to be checked according to Ch 7, Sec 7.

4.6.3 As far as practicable, bottom structure is to be locally fitted with longitudinal primary structure members aligned with side platings of keel fin.

This longitudinal local reinforcement of bottom structure is to be designed to transfer the tensile/compression forces induced by the sides platings of the keel fin to the floors.

4.6.4 As a rule, all the reinforced structural members of the bottom in way of the bulb keel are to be double continuous welded.

4.6.5 Bottom plate rule thickness in way of keel fin is to be not less than:

- the value calculated according to Ch 5, Sec 5 increased by 50% in way of keel fin, or
- the value obtain by direct calculation, bottom plate being considered as the attached plating of floors and longitudinal reinforcement as requested in [4.6.3].

5 Side structure arrangement

5.1 General

5.1.1 In a transverse framing system, structure of sides is made of secondary transverse frames, possibly supported by horizontal stringers.

5.1.2 In a longitudinal framing system, structure of sides are made of secondary longitudinal stiffeners supported by vertical primary supporting members.

5.1.3 Where the connection between side shell and deck plate is rounded, the radius, in mm, is to be not less than 15 t_S, where t_S is the thickness, in mm, of the sheerstrake.

5.2 Stiffener arrangement

5.2.1 Secondary stiffeners are normally to be continuous through the primary supporting members.

Otherwise, the detail of the connection is examined by the Society on a case by case basis.

5.2.2 In general, the section modulus of tweendeck frames is to be not less than that required for frames located immediately above.

5.2.3 Transverse web frames and secondary side frames are to be attached to floors and deck beams by brackets or any other equivalent structure (see Ch 5, Sec 6).

5.2.4 For transverse framing system, the attention of the Designer is drawn on the risk of buckling of side shell plate panels at ends of frames. Extra-thickness or additional vertical intercostal stiffeners may be requested on the side shell.

5.3 Openings in the side shell plating

5.3.1 Openings in side shells are to be well rounded at the corners and located, as far as practicable, well clear of superstructure ends.

5.3.2 Large size openings are to be adequately compensated by means of insert plates of increased thickness. Such compensation is to be partial or total, depending on the stresses occurring in the area of the openings.

5.3.3 Secondary stiffeners cut in way of openings are to be attached to local structural members supported by the continuous adjacent secondary stiffeners, or any other equivalent arrangement.

5.3.4 The sea chest thickness is generally to be equal to that of the local shell plating.

5.3.5 Openings for stabilizer fins are considered by the Society on a case by case basis.

5.4 Additional requirements for side shell plating in way of chain plates of sailing yachts

5.4.1 The present sub-article is applicable to sailing yacht built in steel and aluminium alloys.

5.4.2 Where chain plates are welded directly to the side shell plating, the chain plates are to be inserted in the side shell plating.

where the chain plate thickness is significantly higher than the side shell, chain plate is to be welded to an inserted plate in the side shell. The thickness of this inserted plate is to be intermediate between the thickness of chain plate and thickness of side shell.

Local reinforcements may be requested on the side shell to distribute adequately the loads induced by the chain plate. These local reinforcements are to be connected to the stiffening system of the side shell.

Chain plates scantling are to be in accordance with Ch 7, Sec 6.

6 Deck structure arrangements

6.1 General

6.1.1 Adequate continuity of decks (plates and stiffeners) is to be ensured in way of:

- stepped or knuckled strength decks
- changes in the framing system
- large openings.

6.1.2 Deck supporting structures under cranes and windlass are to be adequately stiffened.

6.1.3 Pillars or other supporting structures are generally to be fitted under heavy concentrated loads on decks.

6.1.4 Stiffeners are also to be fitted in way of the ends and corners of deck houses and partial superstructures.

6.1.5 Beams fitted at side of a deck hatch are to be effectively supported by at least two deck girders located at each side of the deck opening.

6.2 Stiffeners arrangements

6.2.1 Deck longitudinals are to be continuous in way of deck beams and transverse bulkheads.

Other arrangements may be considered provided adequate continuity of longitudinal strength is ensured.

6.3 Opening arrangements

6.3.1 The deck openings are to be as much spaced apart as possible.

As practicable, they are to be located as far as possible from the highly stressed deck areas or from the stepped deck areas.

6.3.2 Extra thickness or additional reinforcements may be requested where deck openings are located:

- in the area of mast foot on sailing yachts
- in the areas of standing rigging chain plates on sailing yachts
- close to the primary transverse cross bulkheads on platform of catamarans
- in areas of deck structural singularity (cockpit, stepped deck...)
- in way of the fixing of out-fittings.

6.3.3 As a rule, all the deck openings are to be fitted with radius corners. Generally, the corner radius is to not be less than 5% of the transverse width of the opening.

6.3.4 Corner radiusing, in the case of two or more openings athwart ship in one single transverse section, is considered by the Society on a case by case basis.

6.4 Additional requirements for deck structure in way of mast of sailing yacht

6.4.1 When deemed necessary by the Society, the transverse buckling strength of deck in way of mast is to be checked according to Ch 5, Sec 9, taking into account the horizontal transversal compression force induced by the horizontal force component of mast shrouds.

Additionally transverse stiffeners or equivalent arrangement may be requested to reduce the panel size submitted to buckling.

6.4.2 An increase of deck thickness may be requested in way of deck openings provided in the area of mast.

6.5 Pillars arrangement under deck

6.5.1 Pillars are to be connected to the bottom at the intersection of girders and floors and at deck at the intersection of deck beams and deck girders.

Where it is not the case, an appropriate local structure (partial floors, partial girders, partial deck beams or partial deck girders) is to be fitted to support the pillars.

As a general rule, heads and heels of pillars are to be attached to the surrounding structure by means of brackets.

Pillars are to be attached at their heads and heels by continuous welding.

Manholes may not be cut in the girders and floors below the heels of pillars.

Tight or non-tight bulkheads may be considered as pillars, provided that their scantling comply with Ch 5, Sec 8.

The scantlings of pillars are to comply with the requirements of Ch 5, Sec 8.

7 Bulkhead structure arrangements

7.1 General

7.1.1 Bulkheads may be horizontally or vertically stiffened.

Stiffening of horizontally framed bulkheads consists of horizontal secondary stiffeners supported by vertical primary supporting members.

Stiffening of vertically framed bulkheads consists of vertical secondary stiffeners which may be supported by horizontal stringers.

The structural continuity of the vertical and horizontal primary supporting members with the surrounding supporting hull structures is to be carefully ensured.

7.1.2 As a general rule, transverse bulkheads are to be stiffened, in way of bottom and deck girders, by vertical stiffeners in line with these girders or by an equivalent system.

Where a deck girder is not continuous, the bulkhead vertical stiffener supporting the end of the deck girder is to be strong enough to sustain the bending moment transmitted by the deck girder.

7.2 Cofferdam arrangement

7.2.1 Definition

A cofferdam means an empty space arranged so that compartments on each side have no common boundary. A cofferdam may be located vertically or horizontally. As a rule, a cofferdam is to be properly ventilated and of sufficient size to allow for inspection.

7.2.2 Arrangement

a) As a rule, cofferdams are to be provided between:
   - fuel oil tanks and lubricating oil tanks
   - compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and compartments intended for fresh water (drinking water, water for propelling machinery and boilers)
   - compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and tanks intended for the carriage of liquid foam for fire-extinguishing systems.

b) Cofferdam separating:
   - fuel oil tanks from lubricating oil tanks
   - lubricating oil tanks from compartments intended for fresh water or boiler feed water
   - lubricating oil tanks from those intended for the carriage of liquid foam for fire-extinguishing systems,

may not be required, when deemed impracticable or unreasonable by the Society in relation to the characteristics and dimensions of the spaces containing such tanks, provided that:

- the common boundary plate thickness of the adjacent tanks is increased, with respect to the thickness obtained according to Ch 5, Sec 5, [2.2], by:
  - 2 mm in the case of tanks carrying fresh water or boiler feed water, and
  - 1 mm in all the other cases
- the sum of the throat thicknesses of the weld fillets at the edges of these plates is not less than the thickness of the plates themselves
- the structural test is carried out with a head increased by 1 m with respect to Ch 5, Sec 11, [3.7].

7.3 Watertight bulkheads

7.3.1 The number and the location of watertight bulkheads are to be in accordance with the relevant requirements of damage stability criteria, when applicable, as defined in Ch 3, Sec 3.

General arrangement of watertight bulkheads are to be in accordance with Ch 2, Sec 1.

7.3.2 Crossing through watertight transverse bulkheads of bottom, side shell or deck longitudinal stiffeners are to closed by watertight collar plates.

7.3.3 Stiffener ends of watertight bulkheads are to be aligned with the hull structure members and are to be fitted with end brackets.

Where this arrangement is made impossible due to hull lines, any other solution may be accepted provided embedding of the bulkhead secondary stiffeners is satisfactorily achieved.

7.3.4 The secondary stiffeners of watertight bulkheads in the tweendecks may be snipped at ends, provided their scantling is increased accordingly.

7.3.5 Watertight doors

The thickness of watertight doors is to be not less than the thickness of the adjacent bulkhead plating, taking into account the actual spacing of the stiffeners.

Where bulkhead stiffeners are cut in way of a watertight door, reinforced stiffeners are to be fitted and suitably overlapped; cross-bars are to be provided to support the interrupted stiffeners.

7.4 Non-tight bulkheads

7.4.1 As a rule, non-tight bulkheads not acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- 0,9 m, for transverse bulkheads
- two frame spacings, with a maximum of 1,5 m, for longitudinal bulkheads.

7.5 Bulkhead acting as pillars

7.5.1 A vertical stiffening member is to be fitted on the bulkhead in line with the deck primary supporting member transferring the loads from the deck to the bulkhead.

This vertical stiffener is to be calculated with the applicable requirements defined for pillar (see Ch 5, Sec 8).

7.6 Bracketed stiffeners

7.6.1 The bracket scantlings at ends of bulkhead stiffeners are carried out by direct calculation, taking into account the bending moment and shear forces acting on the stiffener in way of the bracket as defined in Ch 5, Sec 6.

8 Superstructure and deckhouse structure arrangements

8.1 Connection of superstructures and deckhouses with the hull structure

8.1.1 Superstructure and deckhouse frames are to be fitted, as far as practicable, in way of deck structure and are to be efficiently connected.

Ends of superstructures and deckhouses are to be efficiently supported by bulkheads, diaphragms, webs or pillars.

Where hatchways are fitted close to the ends of superstructures, additional strengthening may be required.

8.1.2 The vertical stiffeners of the superstructure and deckhouse walls of the first tier (directly located above the freeboard deck) are to be attached to the decks at their ends.

Brackets are to be fitted at the lower end, and preferably also the upper end, of the vertical stiffeners of the exposed front bulkheads of engine casings and superstructures.

8.1.3 Connection to the hull deck of corners of superstructures and deckhouses is considered by the Society on a case-by-case basis. Where necessary, local reinforcements may be required.

8.1.4 As a general rules, the side plating at ends of superstructures is to be tapered into the side shell bulwark or the sheerstrake of the strength deck.

Where a raised deck is fitted, the local reinforcement in way of the step is to extend, as a general rules, over at least 3 frame spacings.

8.2 Structural arrangement of superstructures and deckhouses

8.2.1 Web frames, transverse partial bulkheads or other equivalent strengthening of each superstructure tier are to be arranged, where practicable, in line with the transverse reinforced structure below.

Web frames are also to be arranged in way of large openings, tender davits, winches, provision cranes and other areas subjected to local loads.

Web frames, pillars, partial bulkheads and similar strengthening are to be arranged, in conjunction with deck transverses, at ends of superstructures and deckhouses.

8.2.2 Openings

All the openings in superstructure and deckhouses exposed to greenseas are to be fitted with sills or coamings as defined in Ch 2, Sec 2, [3].

The attention of the Interested Party is drawn on the fact that the Flag Administration may request application of National Rules.

8.2.3 Access openings and doors

Access openings cut in sides plating of enclosed superstructures are to be fitted with doors having a strength equivalent to the strength of the surrounding structure.

Special consideration is to be given to the connection of doors to the surrounding structure.

Securing devices which ensure watertightness are to include tight gaskets, clamping dogs or other similar appliances, and are to be permanently attached to the bulkheads and doors. These doors are to be operable from both sides.

8.3 Strengthening of deckhouse in way of tenders and liferafts

8.3.1 Attention is drawn on any possible specific requirements that could be issued by Flag Administration with respect to local structure reinforcement in way of tenders and liferafts.

9 Other structures

9.1 Strengthening for ice navigation

9.1.1 When requested by the Interested Party, an additional ice class notation may be assigned according to NR467, Rules for Steel Ships, Pt A, Ch 1, Sec 2.

Hull strengthening required for the assignment of this additional class notation is defined in NR467 Rules for Steel Ships, Part F, Chapter 8.

The minimum yield stress for scantling criteria of hull structure reinforcements is to be taken equal to:

- R_{eH} for steel structure
- R_y for aluminium structure

where R_{eH} and R_y are defined in Ch 5, Sec 1.

9.2 Thruster tunnel

9.2.1 The thickness of the tunnel is to be not less than that of the adjacent hull plating.

When the tunnel is not welded to the hull, the connection devices are examined by the Society on a case-by-case basis.

9.3 Side and stern doors

9.3.1 Door scantling

Door scantlings are to be designed to offer equivalent strength compared to the adjacent side shell or bulkhead in which they are fitted and are to be examined taking into account the same design loads.

As a rule, the door stiffeners are generally to be considered as simply supported.

9.3.2 Securing and supporting structure

Securing arrangement and supporting structure are to be as defined in NR467 Steel Ships, Pt B, Ch 8, Sec 6, taking into account the permissible local stresses for primary stiffeners defined in Ch 5, Sec 3.

9.3.3 Operating and maintenance manual

The requirements of NR467 Steel Ships, Pt B, Ch 8, Sec 6 [7] are applicable.

9.4 Water jet propulsion tunnel

9.4.1 The drawings of water jet duct, ship supporting structure, thrust bearing, as well as shell openings and local reinforcements are to be submitted for examination.

The pressure in water jet ducts, the forces and moments induced by the water jet to the yacht structure and the calculation procedure from the designer are to be specified.

In no case the scantlings are to be taken less than the requirements for:

- the surrounding hull structure defined in the present Rules
- the requirements defined in NR396 Rules for High Speed Craft, Ch 3, C3.9.2.

9.5 Foils and trim tab supports

9.5.1 Foils and trim tab supports are not covered within the scope of classification and/or certification.

Forces and moments induced by these elements, as well as the designer calculation, are to be submitted for the examination of the surrounding yacht structure reinforcements.

As a general rule, attachment structure of foils to the yacht structure are to be located within watertight compartment or equivalent.

9.6 Side shell bulwark and guard rails

9.6.1 General

The present Subarticle is applicable to bulwarks and guard rails located in the prolongation of the side shell.

The scantling requirements for bulwarks located in other areas are defined in Ch 7, Sec 3.

9.6.2 Scantling of bulwark

a) Plating and secondary stiffeners:

The platings and the secondary stiffeners scantling are to be as defined in Ch 5, Sec 5.

b) Stays:

The section modulus, in cm^3, and the shear section, in cm^2, of stays and their connection to the deck structure in way of the lower part of the bulwark are to be not less than the values obtained from the following formula:

- for section modulus, the greater value obtained from:

  $$z = \frac{500 p_s s \ell^2}{\sigma_{locam}}$$

  and:

  - if $\ell \geq 0{,}6$ m and $s \geq 0{,}6$ m:

    $$z = \frac{280 p_{ssmin}(\ell - 0,3)}{\sigma_{locam}}$$

  - if $\ell \geq 0{,}6$ m and $s < 0{,}6$ m:

    $$z = \frac{600 s p_{ssmin}(\ell - 0,3)}{\sigma_{locam}}$$

  - if $\ell < 0{,}6$ m:

    $$z = \frac{500 p_{ssmin} s \ell^2}{\sigma_{locam}}$$

    with s not taken greater than 0,6 m.

- for shear section, the greater value obtained from:

  $$A_{sh} = \frac{10 p_s s \ell}{\tau_{locam}}$$

  and:

  - if $\ell \geq 0{,}6$ m and $s \geq 0{,}6$ m:

    $$A_{sh} = \frac{2,8 p_{ssmin}}{\tau_{locam}}$$

  - if $\ell \geq 0{,}6$ m and $s < 0{,}6$ m:

    $$A_{sh} = \frac{6 s p_{ssmin}}{\tau_{locam}}$$

  - if $\ell < 0{,}6$ m:

    $$A_{sh} = \frac{10 p_{ssmin} s \ell}{\tau_{locam}}$$

    with s not taken greater than 0,6 m.

where:

p_s : Sea pressure on side shell as defined in Ch 4, Sec 3, [2], in kN/m^2, calculated at mid-height of the stay

p_{ssmin} : Impact pressure on side shell as defined in Ch 4, Sec 3, [3.1.2], in kN/m^2

s : Spacing of stays, in m

ℓ : Length of stays, in m

σ_{locam}, τ_{locam} : Permissible stresses as defined in Ch 5, Sec 3.

9.6.3 Scantling of guard rails

The general arrangement and the scantling of guard rails are to be in accordance with the requirements of NR467 Steel Ships Pt B, Ch 9, Sec 2.

Other arrangement may be considered on the basis of designer calculations.

9.7 Lifting appliances

9.7.1 General

The fixed parts of lifting appliances and their connections to the ship's structure are covered by the present Sub-article, even when the certification (especially the issuance of the Cargo Gear Register) of lifting appliances is not required.

The fixed parts of lifting appliances, considered as an integral part of the hull, are the structures permanently connected to the ship's hull (for instance crane pedestals, masts, king posts, derrick heel seatings, etc., excluding cranes, derrick booms, ropes, rigging accessories, and, generally, any dismountable parts). The shrouds of masts embedded in the ship's structure are considered as fixed parts.

The certification of the lifting appliances may be considered on a case by case basis, at the request of the Interested Party, in accordance with NR526 Rules for the Certification of Lifting Appliances.

9.7.2 Information to be submitted

The following information are to be submitted by the Designer:

- The safe working load (SWL) defined as the maximum static load which may be lifted vertically under normal use within its geometrical limits
- The general arrangement of the lifting equipment specifying the weight of the main elements (crane body, crane boom…)
- When operations are provided at sea, the dynamic amplification factors considered on the static loads to account vessel motions in the most severed sea state conditions.
- The forces and moments transmitted by the crane to the ship structure

9.7.3 Checking criteria

Local reinforcements and hull structure surrounding the crane pedestal are to be checked by direct calculations, taking into account the following permissible stresses:

$\sigma_{VMam} = 0,65\ R_y$

where:

σ_{VMam} : Combined stress calculated according to Von Mises criteria

R_y : Minimum yield stress value defined in Ch 5, Sec 1, [3] or Ch 5, Sec 1, [4].

When inserted plates are provided in deck, side shell or bulkheads in way of crane foundation, these inserts are to have well radiused corners and are to be edge-prepared prior to welding.

9.8 Helicopter deck and platform

9.8.1 Deck and platform provided for the landing and takeoff of helicopter are to be examined as defined in NR600 Ships less than 90 m, Ch 5, Sec 3, taking into account arrangement defined in Pt C, Ch 4, Sec 11.

Note 1: The design and arrangement of the helicopter facilities defined in NR600 are based on the Civil Aviation Publication 437 “Offshore Helicopter Landing Areas - Guidance on Standards” (CAP 437)”. Upon request of the Interested Party, other standards may be considered by the Society on a case by case basis.

9.9 Protection of metallic hull

9.9.1 The protection of hull metallic structure is to be as defined in NR467 Steel Ships, Pt B, Ch 10, Sec 1 and includes the following types of protection:

- coating
- galvanic corrosion in tanks
- wood sheathing of decks
- batten in cargo side.

Section 3 Rule Permissible Stresses and Safety Coefficients

Symbols

R_y : Minimum yield stress, in N/mm² to be taken equal to:
- for steel structures: R_y as defined in Ch 5, Sec 1, [3.1.5]
- for aluminium structures: R_y as defined in Ch 5, Sec 1, [4.1.3].

1 General

1.1 Application

1.1.1 The requirements of the present section define the permissible stresses and safety factors considered for the check of structural members of hull and superstructures of yachts built, totally or partly, in steel or in aluminium alloys.

The permissible stress levels are dependent on:
- the type of loads applied, and
- the type of hull structure element considered

1.2 Global and local stresses

1.2.1 As a rule, the global hull girder stresses, examined when required in Ch 4, Sec 1, [2.2.2] and the local stresses are examined independently.

When deemed necessary according to the global stress level, the hull structure under local stresses may be checked taking into account the global hull girder stresses on a case by case basis according to the methodology defined in NR600 Ships less than 90 m in length.

1.3 Stress notation

1.3.1 The notations used in the present Section for the stresses are:

σ : Bending, compression or tensile stress

τ : Shear stress.

The following indexes are used depending on type of stress considered:

$_{am}$: Rule permissible stress values

$_{gl}$: Stresses resulting from a global strength analysis as defined in Ch 5, Sec 4

$_{loc}$: Stresses resulting from a local strength analysis as defined in Ch 5, Sec 5

$_{VM}$: Combined stress calculated according to Von Mises criteria.

2 Rule permissible stresses

2.1 Permissible stresses under global loads

2.1.1 When the global hull girder strength is examined, the permissible global stresses for plating and for secondary and primary stiffeners, and the safety factors for the buckling check of the structure are defined in Tab 1.

2.2 Permissible stresses under local loads

2.2.1 Plating and secondary stiffeners

The permissible local stresses for the check of plating and secondary stiffeners submitted to local loads, in relation to the type local loads, are defined in Tab 2.

2.2.2 Primary stiffeners

a) Bending and shear stresses of primary stiffeners

The check of primary stiffeners submitted to local loads, in relation to the type of local loads, is to be carried out taking into account the following permissible stresses:

- for analysis through an isolated beam calculation: σ_{locam} and τ_{locam} as defined in Tab 2
- for analysis through a three-dimensional structure beam or a finite element model: σ_{vmam} as defined in Tab 2

b) Buckling of the attached plating of primary stiffeners

When deemed necessary by the Society, the buckling of the attached plating induced by the bending of primary stiffeners under local loads is to be checked along the primary stiffener span.

In this case, the buckling of the attached plating is to comply with the following criteria:

$\sigma_c \geq SF_{buck}\ \sigma_{ac}$

where:

σ_c : Critical buckling stress of the attached plating as defined in Ch 5, Sec 10, [2.4.7]

σ_{ac} : Actual compressive stress in the attached plating induced by the local loads

SF_{buck} : Safety factor defined in Tab 2.

2.2.3 For specific component of the structure, different rule permissible stress values may be taken. In such a case, these specific values are indicated in the dedicated parts of the present Rules, dealing with the specific component under consideration.

2.3 Structure analysis based on finite element calculation

2.3.1 When the hull structure analysis under global loads or local loads is carried out by a finite element calculation submitted to the Society according to Ch 5, Sec 4, [4] or Ch 5, Sec 5, [4.4] respectively, the permissible stresses and buckling safety factors defined in Tab 1 and in Tab 2 is to be respectively increased and reduced by 10%.

Table 1 : Permissible global stresses, in N/mm², and buckling safety factors under global loads

Structure element	Designation	Permissible stress and safety factor
Plating Secondary stiffeners Primary stiffeners	σ_{glam}	0,50 R_y
	τ_{glam}	0,45 R_y
Plating	SF_{buck}	1,35
Secondary stiffeners		1,40
Primary stiffeners		1,40

Table 2 : Permissible local stresses, in N/mm², and buckling safety factors under local loads

Type of loading	Structural element considered	Permissible stresses and safety coefficients
Local sea pressures and internal loads	Plating	σ_{locam} = 0,60 R_y
	Secondary stiffener	σ_{locam} = 0,55 R_y
		τ_{locam} = 0,45 R_y
	Primary stiffeners	σ_{locam} = 0,60 R_y
		τ_{locam} = 0,45 R_y
		σ_{vmam} = 0,60
		SF_{buck} = 1,40
Local dynamic pressures	Plating	σ_{locam} = 0,75 R_y
	Secondary stiffener	σ_{locam} = 0,75 R_y
		τ_{locam} = 0,50 R_y
	Primary stiffeners	σ_{locam} = 0,90 R_y
		τ_{locam} = 0,50 R_y
		σ_{vmam} = 0,90 R_y
Tank testing loads and flooding loads	Plating	σ_{locam} = 0,85 R_y
	Secondary stiffener	σ_{locam} = 0,85 R_y
		τ_{locam} = 0,50 R_y
	Primary stiffeners	σ_{locam} = 0,90 R_y
		τ_{locam} = 0,50 R_y
		σ_{vmam} = 0,9 R_y

Section 4 Global Hull Girder and Platform Scantling

1 General

1.1 Application

1.1.1 The global strength analysis is to be carried out when deemed necessary as defined in Ch 4, Sec 1, [2.2.2] in order to check the hull girder stresses in relation to the:

- global hull girder loads defined in Ch 4, Sec 2, and
- the maximum permissible stresses and buckling criteria defined in Ch 5, Sec 3.

1.1.2 Material

The global strength analysis of monohull and multihull is to be carried out according to:

- for steel structure: the present Section
- for aluminium alloys structure: the present section and NR561 Aluminium Ships.

1.2 Global strength calculation

1.2.1 General

The global strength analysis is to be carried out according to:

- [2] and [3] for monohull and catamaran respectively, or
- finite element calculation according to [4], or
- an equivalent alternative calculation approach submitted by the designer

1.3 Strength characteristics

1.3.1 Section modulus

The section modulus in any point of a transverse section of a member contributing to the longitudinal and/or transversal global strength is given, in m^3, by the following formula:

$$Z_A = \frac{I_Y}{|z - N|}$$

where:

I_Y : Moment of inertia, in m^4 of the transverse section of member considered, calculated taking into account [1.3.2] and all the continuous structural elements of the hull contributing to the longitudinal and/or transversal strength with respect to the horizontal neutral axis

z : Z co-ordinate, in m, of the considered point in the transverse section above the neutral axis of the section

N : Z co-ordinate, in m, of the centre of gravity of the transverse section, above the base line.

1.3.2 Equivalent thickness for material other than steel

Where a member contributing to the longitudinal and/or transversal strength is made in material other than steel with a Young's modulus E equal to 2,06 10^5 N/mm², the steel equivalent thickness to take into account for the calculation of the inertia of the considered section is obtained, in mm, from the following formula:

$$t_{SE} = \frac{E}{2{,}06.10^5} t_M$$

where:

t_M : Thickness, in mm, of the member under consideration

E : Young modulus, in N/mm², of the considered member.

1.3.3 Section moduli at bottom and deck

The section moduli at bottom and deck are given, in m^3, by the following formulae:

- at bottom:

$$Z_{AB} = \frac{I_Y}{N}$$

- at deck:

$$Z_{AD} = \frac{I_Y}{V_D}$$

where:

I_Y, N : Defined in [1.3.1]

V_D : Vertical distance, in m, equal to: $V_D = z_D - N$

z_D : z co-ordinate, in m, of the deck, above the base line.

1.4 Global strength check

1.4.1 Overall stresses

a) General case:

The overall bending and shear stresses, in N/mm², in any point of a transverse section of a member contributing to the longitudinal and/or transversal global strength is obtained by the following formula:

$$\sigma_A = \frac{M_V}{Z_A} 10^{-3}$$

$$\tau_A = \frac{Q_v S_v V}{I_y t}$$

where:

M_V, Q_v : Overall bending moments, in kN.m, and shear forces, in kN, induced by the loading cases considered

Z_A : Section modulus, in m³, calculated according to [1.3.3].

S_v : Vertical section, in m², located above the point considered in the section taking into account [1.3.2]

V : Vertical distance, in m, between the centre of gravity of the vertical section S_v and the centre of gravity of the whole transverse section

I_y : Moment of inertia, in m⁴ as defined in [1.3.1]

t : Thickness, in mm, of the element where the shear stress is calculated.

b) Overall stress for element other than steel:

For element other than steel, the stresses σ_A and τ_A calculated according to a) are to be corrected by the ratio between the Young modulus of the considered element and the steel Young modulus taken equal to $2,06.10^5$ N/mm² for σ_A, and by the ratio between the Shear modulus of the considered element and the steel Shear modulus taken equal to $7,93.10^4$ N/mm².

c) Simplified method for the calculation of the shear stress:

When the inertia of a section is not determined, the shear stress in a section may be calculated as follow:

- The total shear section S_A of the section may be considered as equal to the sum of the vertical sections of the:
  - for longitudinal strength analysis: Side shells and longitudinal bulkheads contributing to the global strength of the hull girder
  - for transversal strength analysis of catamaran: Transversal bulkheads contributing to the global strength of the platform.
- The shear stress may be taken equal to:

$$\tau_A = \frac{Q_v}{S_A} 10^{-3}$$

- Where a member is made in material other than steel with a shear modulus G equal to $7,93.10^4$ N/mm², the steel equivalent thickness that may be included for the calculation of the section S_A of the considered section is obtained, in mm, from the following formula:

$$t_{SE} = \frac{G}{7,93 \cdot 10^4} t_M$$

where:

t_M : Thickness, in mm, of the member under consideration

G : Shear modulus, in N/mm², of the considered member.

The shear stresses τ_A are to be corrected by the ratio between the shear modulus of the considered element and the steel shear modulus taken equal to $7,93.10^4$.

1.4.2 Stress check

a) Maximum stress check:

It is to be checked that the actual normal stresses σ_A, in N/mm², and shear stresses τ_A, in N/mm², calculated according to [2.2] and [2.3] for monohull and to [3.4] and [3.5] for catamaran are in compliance with the following criteria:

$$|\sigma_A| \le \sigma_{glam}$$

$$|\tau_A| \le \tau_{glam}$$

where:

σ_{glam} : Global bending permissible stress, in N/mm², as defined in Ch 5, Sec 3

τ_{glam} : Global shear permissible stress, in N/mm², as defined in Ch 5, Sec 3.

b) Buckling check:

It is to be checked that the actual normal stresses σ_A and shear stresses τ_A calculated according to [2.2] and [2.3] for monohull and to [3.4] and [3.5] for catamaran are in compliance with the criteria defined in Ch 5, Sec 9, [4] for plating and Ch 5, Sec 10, [2.3] for stiffeners.

2 Calculation of global strength for monohull

2.1 Longitudinal hull girder inertia

2.1.1 The calculation of the hull girder inertia is to be carried out taking into account all the longitudinal continuous structural elements of the hull.

A superstructure extending over at least 0,4 L may generally be considered as contributing to the longitudinal strength.

The sectional areas of openings such as deck hatches, side shell ports, side shell and superstructure doors and windows, in the members contributing to the longitudinal hull girder strength, are to be deduced from the considered section.

Lightening holes, draining holes and single scallops in longitudinal stiffeners need not be deduced if their height is less than 0,25 h_W without being greater than 75 mm, where h_W is the web height, in mm, of the considered longitudinal.

2.2 Overall stresses calculation for monohull motor yacht

2.2.1 Overall stresses check

The overall stresses along the hull are to be calculated according to [1.4.1] taking into account the loading combinations defined in [2.2.2].

These overall stresses are to fulfill the requirements defined in [1.4.2].

2.2.2 Head sea conditions

The overall bending moments and shear force, in head sea condition, are to be taken equal to:

M_V : Overall bending moment induced by still water and wave loads, in kN.m, calculated as follow:

- in hogging conditions: $M_V = M_{SW} + M_{WV}$
- in sagging conditions: $M_V = -M_{WV}$

Q_A : Vertical shear force induced by still water and wave loads, in kN, calculated as follow:

$Q_A = Q_{SW} + Q_{WV}$

where:

M_{SW}, M_{WV}: Still water bending moment defined in Ch 4, Sec 2, Tab 1 and wave bending moment defined in Ch 4, Sec 2, [3.2.1]

Q_{SW}, Q_{WV}: Still water shear force defined in Ch 4, Sec 2, Tab 1 and wave shear force defined in Ch 4, Sec 2, [3.2.1]

The longitudinal distribution along the hull of the bending and shear stresses is to be taken as defined in Ch 4, Sec 2, [3.2.4].

2.3 Overall stresses calculation for monohull sailing yacht

2.3.1 Overall stresses check

The overall stresses along the hull are to be taken equal to the stresses calculated according to [1.4.1] taking into account the loading combinations defined in [2.3.2] with [2.3.3] a) or b).

These overall stresses are to fulfill the requirements defined in [1.4.2].

2.3.2 Head sea condition

The overall bending moments and shear force, in head sea condition, are to be taken equal to:

M_V : Overall bending moment induced by still water and wave loads, in kN.m, in sagging condition, equal to:

$M_V = -M_{SW} - M_{WV}$

Q_A : Vertical shear force induced by still water and wave loads, in kN, in sagging condition, equal to:

$Q_A = Q_{SW} + Q_{WV}$

where:

M_{SW}, M_{WV}: Still water bending moment defined in Ch 4, Sec 2, Tab 1 and wave bending moment defined in Ch 4, Sec 2, [3.2.1]

Q_{SW}, Q_{WV}: Still water shear force defined in Ch 4, Sec 2, Tab 1 and wave shear force defined in Ch 4, Sec 2, [3.2.1]

The longitudinal distribution along the hull of the bending and shear stresses is considered as defined in Ch 4, Sec 2, [3.2.4].

2.3.3 Rig loads condition

a) Sailing monohull with one mast:

The overall bending moment (to be considered as negative) and shear force induced by rig loads, are to be taken equal to:

M_V : Overall bending moment induced by rig loads, in kN.m, equal to $-0,7M_{RIG}$

Q_A : Vertical shear force induced by rig loads, in kN, equal to $0,7Q_{RIG}$

where:

M_{RIG} : Bending moment defined in Ch 4, Sec 2, [5.1.1]

Q_{RIG} : Shear force defined in Ch 4, Sec 2, [5.1.2]

The longitudinal distribution along the hull of the bending stresses is considered as maximum in way of the mast and equal to zero at each ends of the hull.

b) Sailing monohull with several masts:

The overall bending moment (to be considered as negative values) and shear force induced by rig loads are to be determined by a beam model calculation.

The beam model calculation is to be carried out with the following hypothesis:

- the hull is considered as a continuous beam having vertical bending inertia and shear section close to the actual hull,
- each mast is considered as a vertical support to the continuous beam,
- the continuous beam is vertically loaded by 70% of the various vertical components of design forces F_{Vi} , F_{Di} , F_{mi} , F_{Ei} and F_P exerted by the standing rigging as defined in Ch 4, Sec 2, [5.2.1].

When the top of the masts are linked by horizontal top mast shroud, the calculation of the hull girder bending moments induced by standing rigging loads is to be carried out on a case by case basis.

3 Calculation of global strength for catamaran

3.1 Calculation approach for catamaran

3.1.1 The global strength analysis of catamaran yacht is to be carried out taking into account the different elementary beam model analysis, or their combinations, as defined in the present Article.

3.2 Longitudinal float girder and primary transverse cross structure of platform inertias

3.2.1 Longitudinal float girder inertias

The floats inertias to take into account for the global strength analysis are to be representative of the:

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

of the actual floats.

The calculation of the float girder inertia is to be carried out taking into account all the longitudinal continuous structural elements of the float.

The sectional areas of openings such as deck hatches, side shell ports, side shell and superstructure doors and windows, in the members contributing to the longitudinal float girder strength, are to be deduced from the considered section.

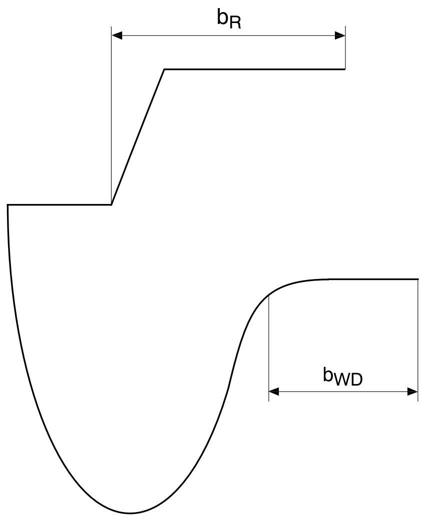
Lightening holes, draining holes and single scallops in longitudinal stiffeners need not be deduced if their height is less than 0,25 h_W without being greater than 75 mm, where h_W is the web height, in mm, of the considered longitudinal.

A platform extending over at least 0,4 L may generally be considered as contributing to the longitudinal strength of the float. In this case, all the longitudinal continuous members of the platform located in the areas b_R and b_{WR} according to Fig 1 are to be considered in the calculation of the floats inertias, where:

b_R : Breadth equal to 10% of the longitudinal platform deck length

b_{WD} : Breadth equal to 10% of the longitudinal platform bottom length.

Figure 1 : Area to take into account for continuous members (plates and stiffeners) for float girder inertia



3.2.2 Primary transverse cross structure inertias of the platform

The primary transverse cross structure elements of the platform to take into account for the global strength analysis are to be representative of the:

- vertical bending inertias,
- shear inertia,
- torsional inertia about longitudinal cross structure element axis for element having a closed section,

of the actual primary transverse cross structure elements of the platform.

The calculation of the primary transverse cross structure elements inertia is to be carried out taking into account all the continuous structural elements.

The sectional areas of openings such as deck hatches, doors and windows, in the primary transverse cross structure elements are to be deduced from the considered section.

Lightening holes, draining holes and single scallops in stiffeners need not be deduced if their height is less than 0,25 h_W without being greater than 75 mm, where h_W is the web height, in mm, of the considered stiffener.

3.3 Hull structure basic model

3.3.1 General

The global strength analysis of catamaran is to be carried out by direct calculations and 2D beam analysis combinations.

The basic 2D model, as shown on Fig 2, used for the global strength analysis is defined as follow:

- one float is represented by beams having the characteristics defined in [3.2.1]. The other float is represented by the fixed conditions of the model
- the primary transverse cross structure elements of the platform are represented by beams having the characteristics defined in [3.2.2], and lengths equal to the distance between inner side shell of floats at the section considered.

  When a large round corner is provided at the connection between the float and the primary transverse cross structure of the platform, the length of the primary transverse cross structure is to be taken equal to the distance measured at mid radius of the round corners.

Note 1: The fore cross beam supporting the fore stay fixed to the floats by hinges is not to be considered in the hull structure basic model. In this case, the fore cross beam is to be checked by a local beam analysis as defined in [3.5.3].

3.4 Overall stresses calculation for catamaran motor yacht

3.4.1 Overall stresses check

The overall stresses calculated according to [1.4.1] are to fulfill, for each independent cases defined in [3.4.2] a), b) and c) the requirements defined in [1.4.2].

Figure 2 : Cross platform of catamaran - Basic model

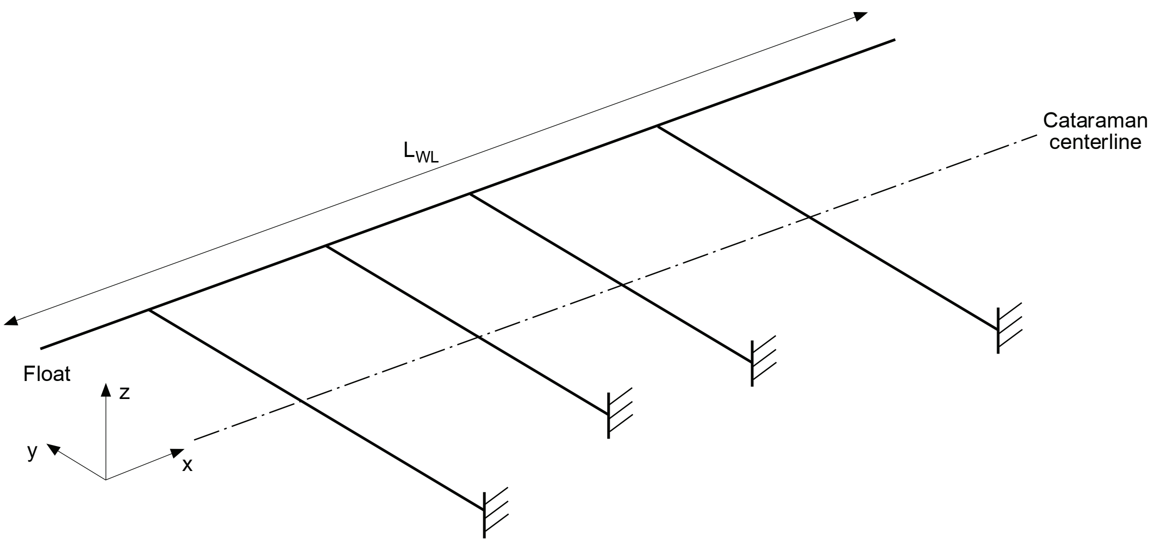
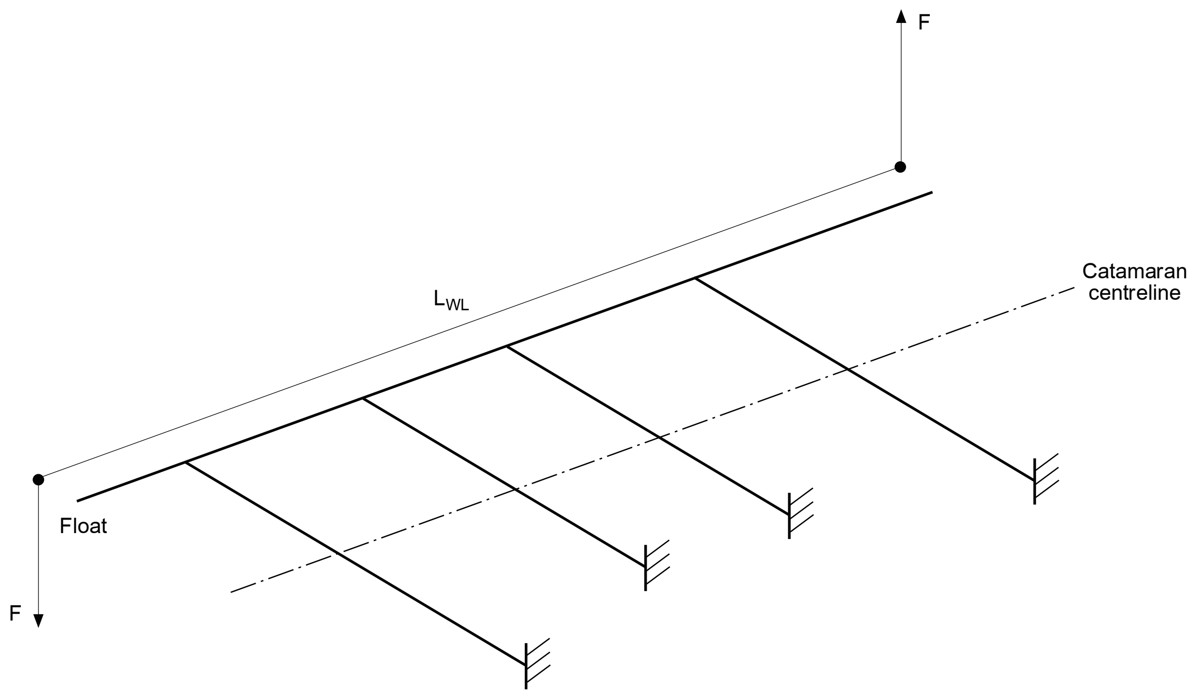


Figure 3 : Loading model for quartering sea conditions



3.4.2 Elementary loading cases

a) Head sea condition:

The overall bending moments and shear force to be applied to the floats are to be taken equal to:

M_V : Overall bending moment induced by still water and wave loads, in kN.m, calculated as follow:

- in hogging conditions:

  $M_V = M_{SW} + M_{WV}$

- in sagging conditions:

  $M_V = -M_{WV}$

Q_A : Vertical shear force induced by still water and wave loads, in kN, calculated as follow:

$Q_A = Q_{SW} + Q_{WV}$

where:

M_{SW}, M_{WV}: Still water bending moment defined in Ch 4, Sec 2, Tab 1 and wave bending moment defined in Ch 4, Sec 2, [3.2.1], taking into account Ch 4, Sec 2, [3.2.3]

Q_{SW}, Q_{WV}: Still water shear force defined in Ch 4, Sec 2, Tab 1 and wave shear force defined in Ch 4, Sec 2, [3.2.1], taking into account Ch 4, Sec 2, [3.2.3]

The longitudinal distribution along the float of the bending and shear stresses is considered as defined in Ch 4, Sec 2, [3.2.4].

b) Quartering sea conditions:

The overall bending moments and shear forces to be applied to the floats and the primary transverse cross structure are to be deduced from a 2D beam model, in kN.m.

The 2D beam model to consider is the basic model defined in [3.3] loaded as indicated in Fig 3, where F is to be taken as follow:

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

where:

M_{WT} : Wave torque moment, in kN.m, calculated according to Ch 4, Sec 2, [3.3.1]

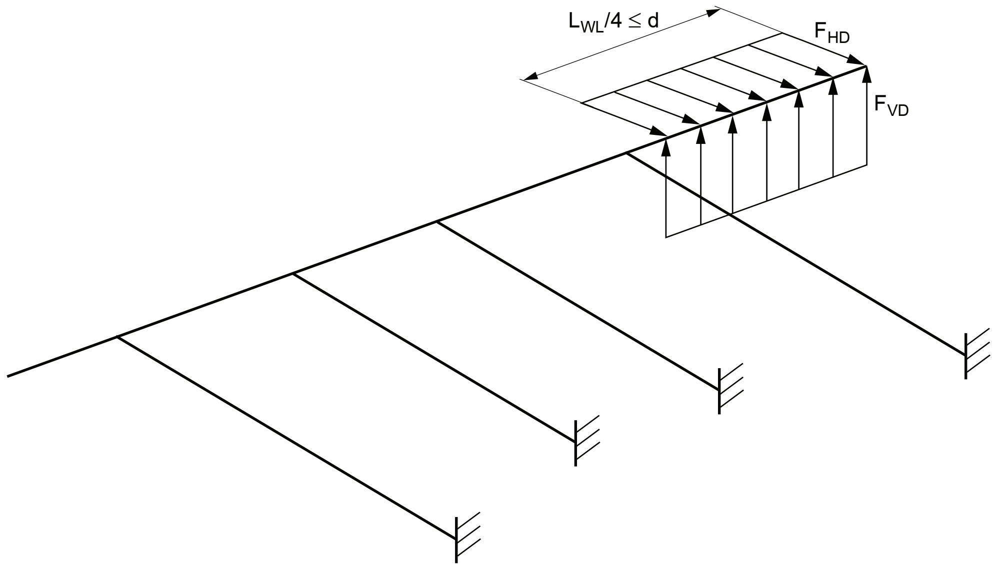
L_{WL} : Waterline length of the float at full load waterline, in m.

As a general rule, two successive loading cases are to be considered:

- the case as shown in Fig 3 when the fore part of the float is on the wave crest, and
- the same case with forces in the opposite direction when the aft part of the float is on the wave crest.

The longitudinal distribution along the float and the transverse primary cross structure is defined by the 2D beam calculation.

Figure 4 : Loading model for digging in wave condition



c) Digging in wave conditions:

The overall bending moments and shear forces to be applied to the float and the primary transverse cross structure are to be taken equal to:

M_V : Bending moments along the float and the primary transverse cross structures deduced from a 2D beam model, in kN.m

Q_A : Vertical shear forces along the float and the primary transverse cross structures deduced from a 2D beam model, in kN

The 2D beam model to consider is the basic model defined in [3.3] loaded by the linear loads F_{VD} and F_{HD} , in kN/m, as indicated in Fig 4, where:

$F_{VD} = F_{vm} - F_{vl}$

$F_{HD} = F_{hm} - F_{hl}$

where:

F_{vm}, F_{vl}, F_{hm}, F_{hl}: Fore float loads defined in Ch 4, Sec 2, [4.2.1]

The vertical and horizontal linear loads F_{VD} and F_{HD} are to be applied from the fore part of the float on a distribution length, in m, equal to L_{WL} / 4 without being taken greater than d, where:

L_{WL} : Length at waterline at full load, in m

d : Length, in m, of digging in wave, equal to the distance between the extreme fore end of each float and the forward part of the platform.

The longitudinal distribution along the float and the transverse primary cross structure is defined by the 2D beam calculation.

3.5 Overall stresses calculation for catamaran sailing yacht

3.5.1 Overall stresses calculation

The overall bending and shear stresses induced by the different loads induced by sea conditions and rig loads in any point of a transverse section of the float and the transverse cross structures are to be taken equal to:

- the overall stresses calculated according to [1.4.1] for the elementary loading cases defined in [3.5.2] a), b), c) and d) and in [3.5.3] a), b) and c) for each independent cases, and
- the sum of the overall stresses calculated according to [1.4.1] for the loading case combinations defined in Tab 1.

Table 1 : Overall combined stresses

Loading conditions		Head sea	Quartering sea	Digging in wave	Rig loads	Mast compression	Mainsail track force
Reference		[3.5.2], item a)	[3.5.2], item b)	[3.5.2], item c)	[3.5.2], item d)	[3.5.3], item a)	[3.5.3], item b)
Primary structure element	Float	X			X		
			X		X		
				X			
	Transverse cross beam in way of mast	X			X	X	
			X		X	X	
				X			
	Transverse cross beam in way of mainsail track	X			X **(1)**		X
			X		X **(1)**		X
				X			
	Other transverse cross beams	X			X		
			X		X		
				X			

(1) In this case, the force F_p considered in the elementary loading case defined in [3.5.2] d) applied to the beam model is to be taken equal to the force applied on backstay only, regardless the mainsheet force.

3.5.2 Elementary loading cases

a) Head sea conditions:

The overall bending moment and shear force, in head sea condition to be applied to the floats are to be taken equal to:

M_V : Overall bending moment induced by still water and wave loads, in kN.m, in hogging and sagging conditions, equal to:

- In hogging condition: $M_V = M_{SW} + M_{WV}$
- In sagging condition: $M_V = -M_{WV}$

Q_A : Vertical shear force induced by still water and wave loads, in kN, in sagging condition, equal to:

$Q_A = Q_{SW} + Q_{WV}$

where:

M_{SW}, M_{WV}: Still water bending moment defined in Ch 4, Sec 2, Tab 1 and wave bending moment defined in Ch 4, Sec 2, [3.2.1] taking into account Ch 4, Sec 2, [3.2.3]

Q_{SW}, Q_{WV}: Still water shear force defined in Ch 4, Sec 2, Tab 1 and wave shear force defined in Ch 4, Sec 2, [3.2.1] taking into account Ch 4, Sec 2, [3.2.3]

The longitudinal distribution along the float and the transverse primary cross structures is defined by the 2D beam calculation.

b) Quartering sea conditions:

The overall bending moments and shear forces to be applied to the float and primary transverse cross structures are to be calculated as defined in [3.4.2] b).

c) Digging in wave conditions:

The overall bending moments and shear forces to be applied to the float and primary transverse cross structures are to be calculated as defined in [3.4.2] c).

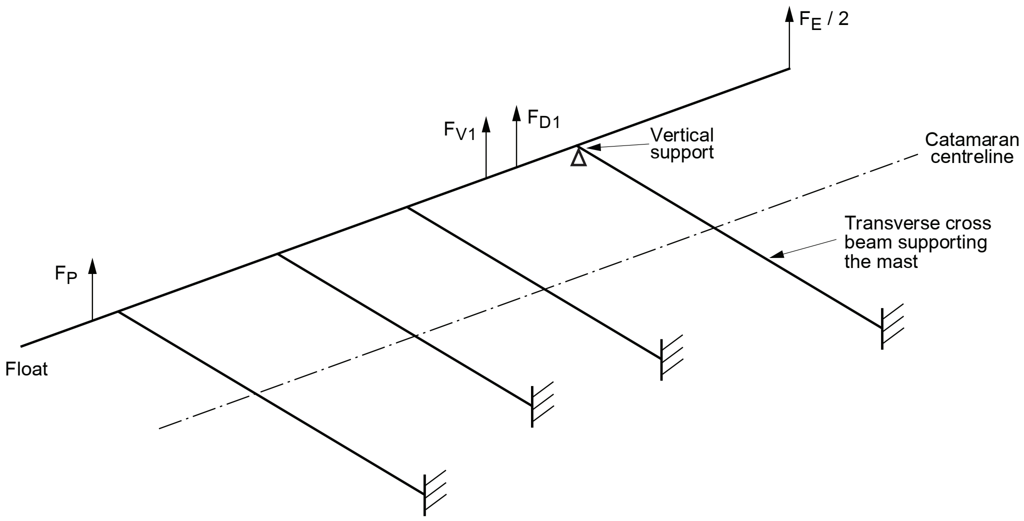
d) Rig loads conditions applied to the platform:

The overall bending moments and shear forces induced by the rig loads to be applied to float and transverse cross structures are to be determined by a beam model calculation.

The beam model to consider is the basic beam model defined in [3.3] and the following additional hypothesis according to Fig 5:

- a vertical support is to be provided at the connection between the float and the transverse cross structure element supporting the mast,
- the float is vertically loaded by 70% of the various vertical components of design forces F_{Vi}, F_{Di}, F_P (equal to the sum of design forces applied on backstay and mainsheet) and $F_E/2$ exerted by the standing rigging as defined in Ch 4, Sec 2, [5.3].

Figure 5 : Loading model for rig loads condition



3.5.3 Elementary stresses calculation for specific structure elements

a) Transverse cross structure under mast compression force:

The overall bending and shear stresses induced by the mast compression force in any point of a transverse section of the transverse cross structures supporting the mast are to be calculated by an isolated beam calculation defined as follow:

- the transverse cross structure element supporting the mast is to be represented by a beam as defined in [3.2.2] having a length equal to the distance between inner side shell of floats at the section considered and fixed at their ends (displacement and rotation),

Note 1: When a large round corner is provided at the connection between the float and the primary transverse cross structure of the platform, the length of the primary transverse cross structure is to be taken equal to the distance measured at mid radius of the round corners.

- 100% of the maximum design mast compression force is to be applied at mid span of the transverse cross structure element supporting the mast.

b) Transverse cross structure supporting the mainsail track:

The overall bending and shear stresses induced by the mainsail track force in any point of a transverse section of the transverse cross structures supporting the mainsail track are to be calculated by an isolated beam calculation defined as follow:

- the transverse cross structure element supporting the mainsail track is to be represented by a beam as defined in [3.2.2] having a length equal to the distance between inner side shell of floats at the section considered and fixed at their ends (displacement and rotation),
- the mainsheet vertical force is to be applied at mid span of the transverse cross structure element supporting the mainsail track.

c) Fore cross beam:

As defined in Ch 7, Sec 6, [3].

4 Global strength analysis for monohull and catamaran by finite element calculation

4.1 General

4.1.1 This Article is a guidance for the stress check (maximum and buckling stresses) of hull girder and platform structure loaded under global hull girder loads only using a finite element complete ship model.

4.2 Structural model

4.2.1 General

The complete ship is to be modeled so that the elements contributing to global strength or leading to shear deformation are properly taken into account.

Long superstructures are to be modeled in order to also reproduce the correct hull global strength, in particular the contribution of each superstructure deck to the hull girder longitudinal strength.

Special attention is to be brought to the following structural elements which are to be correctly represented:
- deck structure, with particular attention to deck openings
- transverse and longitudinal bulkheads, with particular attention to door openings
- transverse web frames
- pillars
- vertical stiffeners in way of windows
- ends of superstructure and their fixation to deck
- side shell openings.

The following structural elements may be disregarded:
- small deck openings (less than typical size of elements)
- openings in webs of primary supporting members when their height is less than 50% of the web height, provided that a detailed analysis is performed for the assessment of these primary supporting members according to Ch 5, Sec 5, [4].

4.2.2 Finite elements

The shell element mesh is to follow the stiffening system as far as practicable, hence representing the actual plate panels between stiffeners.

Shell elements are to be used to represent plating. As a rule, the aspect ratio of shell elements is generally not to be greater than 2, and in no case greater than 4.

Angles of quadrilateral elements are to be greater than 60° and less than 120°. Angles of triangular elements are to be greater than 30° and less than 120°.

Ordinary stiffeners are to be modeled with bar elements and may be grouped at regular intervals.

Webs of primary structure are to be modeled with shell elements.

Face plates of primary structure may be modeled with rod or bar elements.

Pillars may be modeled by bar elements. Their bending properties and their connections to deck are to be accurately represented.

In order to account for the shear deformation of deckhouses and superstructure sides, at least three elements in each direction of the strips between the windows are to be modeled.

4.3 Loads distribution and boundary conditions

4.3.1 Loads distribution

a) General

Hull girder loads distributions are divided in still water hull girder load distributions and wave hull girder load distributions.

Hull girder load distributions are obtained by applying fictitious vertical loads at specific longitudinal locations.

The structural elements selected for the application of such loads are to be chosen such as to avoid fictive local stress and generally to be those of high vertical stiffness.

Hull girder load distributions are to target the bending moments and shear forces distributions defined in Ch 4, Sec 2.

Detailed justifications of the loading distributions may be requested by the Society to verify the values of the actual global bending moments and shear forces applied to the model.

b) Rigging loads

When deemed necessary, the global rigging loads are to be considered on a separately additional calculation model.

In this case, the stresses induced by the global rigging loads are to be added to the stresses calculated according to a).

4.3.2 Boundary conditions

The finite element calculation is to be performed with displacement restrictions applied to nodes of the model. Rotations of these nodes are to be free.

As a rule, these nodes are to be located outside the model areas where global stress checks are carried out.

Detailed justifications may be requested by the Society to verify that the forces reactions applied to these nodes do not affect the global bending moments and shear forces applied to the model.

4.4 Stress check

4.4.1 Stress components

Stress components are generally identified with respect to the element co-ordinate system. The orientation of the element co-ordinate system in relation to the reference co-ordinate system of the model is to be specified.

The following stress components to be considered and calculated at the centroid of each element are:
- the normal stresses σ_1 and σ_2 in the directions of element co-ordinate system axes
- the shear stress τ_{12} with respect to the element co-ordinate system axes

4.4.2 Stress check

The maximum stresses and buckling stresses are to be calculated as follow:

a) Maximum stress check:

The Von Mises equivalent stress, σ_{eq}, in N/mm², is to be derived as follows:

$$\sigma_{eq} = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2 + 3\tau_{12}^2}$$

Where σ_1, σ_2 and τ_{12} are defined in [4.4.1].

b) Buckling stress check:

Where the buckling panel is meshed by several finite plate elements, the stresses of the buckling panel are obtained by the following methodology:

- For each plate finite element, the stresses ($\sigma_{\xi\varepsilon}{}^*$, $\sigma_{\psi\varepsilon}{}^*$, $\tau_\varepsilon{}^*$) expressed in the element co-ordinate system are projected in the co-ordinate system of the buckling panel to obtained the stresses ($\sigma_{\xi\varepsilon}$, $\sigma_{\psi\varepsilon}$, τ_ε).
- For the buckling panel, the stresses are calculated according to the following formula:

$$\sigma_x = \frac{\sum_i^n A_i \sigma_{x\,e_i}}{\sum_i^n A_i} \geq 0$$

$$\sigma_y = \frac{\sum_i^n A_i \sigma_{y\,e_i}}{\sum_i^n A_i} \geq 0$$

$$\tau = \frac{\sum_i^n A_i \tau_{e_i}}{\sum_i^n A_i} \geq 0$$

where:

$\sigma_{\xi\,\varepsilon\iota}$, $\sigma_{\psi\,\varepsilon\iota}$: Stresses, in N/mm², of the plate finite element i, taken equal to 0 in case of tensile stress

τ_{ei} : Shear stress, in N/mm², of the plate finite element i

A_i : Area, in mm², of the plate finite element i.

4.4.3 Scantling criteria

The maximum actual stresses and buckling stresses are to fulfill the permissible global stresses and buckling safety factors defined in Ch 5, Sec 3, Tab 1 taking into account Ch 5, Sec 3, [2.3].

Section 5 Plating, Ordinary and Primary Stiffener Local Scantling

1 General

1.1 Materials

1.1.1 The requirements of the present section are applicable for the local scantling of yacht structure built of steel and aluminium alloys.

For hull or superstructure built of aluminium alloys, these requirements are to be applied together with NR561 Hull in Aluminium Alloys.

1.2 Local scantling consideration

1.2.1 The present section deals with the local scantling of plating, secondary and primary stiffeners under lateral pressure.

The scantling of platings, secondary and primary stiffeners contributing to the overall longitudinal strength of the hull girder and to the overall transverse strength of transverse cross platform of catamaran are also to be checked as defined in Ch 5, Sec 4.

1.3 Local load point location

1.3.1 Sea pressures

Unless otherwise specified, the sea pressures are to be calculated:

- for plate panel: at the lower edge of the plate panel
- for longitudinal stiffener: at mid-span of the stiffener
- for transverse stiffener: at the lower ($p_{S\ lower}$) and upper ($p_{S\ upper}$) points of the stiffener.

1.3.2 Dynamic sea pressures

Unless otherwise specified, the dynamic sea pressures are to be calculated:

- for plate panel: at the mid edge of the plate panel
- for longitudinal and transversal stiffener: at mid-span of the stiffener.

2 Plating scantling

2.1 General

2.1.1 Local scantling of platings are to be checked under the following loads:

- for bottom platings: sea pressure and bottom slamming pressures (when slamming may occur)
- for side shell and bottom platform platings: sea pressure and side shell impacts
- for deck and superstructure platings: The greater value between sea pressure and minimum loads
- for tanks: local internal pressure and testing loads
- for watertight bulkheads fitted for damage stability: flooding loads.

2.2 Plating scantling

2.2.1 Minimum thickness

As a rule, the thickness, in mm, of plates calculated according to the present Section are not to be less than:

- for steel plate: 0,035 $L_W\ k^{1/2}$ + 3,0
- for aluminium plate: 4 mm
- for aluminium extruded panel: 3 mm.

where:

L_w : $L_w = 0{,}5\ (L_{WL} + L_{HULL})$

k : Material factor defined in Ch 5, Sec 1.

2.2.2 Plating scantling under sea pressure

As a rule, the thickness of plating subjected to lateral pressure is to be not less than the value obtained, in mm, from the following formula:

$$t = 22,4\lambda\mu s\sqrt{\frac{p}{\sigma_{locam}}}$$

where:

λ : Corrosion coefficient taken equal to:

For plating located in superstructure and roof:

- for steel plating: λ = 1,05
- for aluminium plating: λ = 1

In other cases:

- for steel plating: λ = 1,10
- for aluminium plating: λ = 1,05

μ : Aspect ratio coefficient of the elementary plate panel, equal to:

$$\mu = 1,21\sqrt{1+0,33\left(\frac{s}{\ell}\right)^2} - 0,69\frac{s}{\ell} \le 1$$

s : Length, in m, of the shorter side of the plate panel

ℓ : Length, in m, of the longer side of the plate panel

p : Local sea pressures or internal pressures, in kN/m², as defined in Ch 4, Sec 3, [2.1] and Ch 4, Sec 4

σ_{locam} : Local permissible bending stress, in N/mm², as defined in Ch 5, Sec 3, [2.2], for local sea pressure.

2.2.3 Plating scantling under slamming pressure

As a rule, the thickness of plating subjected to slamming pressure is to be not less than the value obtained, in mm, from the following formula:

$$t = 22,4\lambda n_p \mu s\sqrt{\frac{p}{\sigma_{locam}}}$$

where:

λ, μ : As defined in [2.2.2]

p : bottom slamming pressure, p_{sl}, in kN/m², as defined in Ch 4, Sec 3, [3.2.2]

n_p : Coefficient to be taken equal to:

- for steel plating: n_p = 0,77
- for aluminium plating: n_p = 0,85

σ_{locam} : Local permissible bending stress, in N/mm², as defined in Ch 5, Sec 3, [2.2], for local dynamic pressure.

2.2.4 Plating scantling of side shell under impact pressure

As a rule, the thickness of side shell plating and of platform bottom plating for multihull subjected to impact pressure is to be not less than the value obtained, in mm, from the following formula:

- if s ≤ 0,6 m

$$t = 17,3\sqrt{\frac{1}{\ell_{ssi}}}\lambda n_p \mu s\sqrt{\frac{p}{\sigma_{locam}}}$$

- if s > 0,6 m

$$t = 13,4\sqrt{\frac{1,5s^2-0,18}{\ell_{ssi}s}}\lambda n_p \mu\sqrt{\frac{p}{\sigma_{locam}}}$$

where:

λ, μ, ℓ : As defined in [2.2.2]

p : Pressure, in kN/m², to be taken equal to: $p = C_p P_{ssmin}$

p_{ssmin} : Impact pressure on side shell and, for multihull, on platform bottom, in kN/m², as defined in and Ch 4, Sec 3, [3.1]

C_p : Pressure coefficient equal to: $C_p = -0,98s^2 + 0,3s + 0,95 \ge 0,8$

n_p : Coefficient to be taken equal to:

- for steel plating: n_p = 0,77
- for aluminium plating: n_p = 0,85

ℓ_{ssi} : Length, in m, equal to: $\ell_{ssi} = 0,6\,(1 + s) \le \ell$

σ_{locam} : Local permissible bending stress, in N/mm², as defined in Ch 5, Sec 3, [2.2], for local dynamic pressure.

The present requirement is also applicable for the scantling check of platings located in the lowest tier of sidewalls of superstructure and bulwarks in prolongation of the side shell.

3 Secondary stiffener scantling

3.1 General

3.1.1 Loading cases

Local scantlings of secondary stiffeners are to be checked under the following loading:

- for bottom stiffeners: wave loads and bottom slamming loads (when slamming may occur)
- for side shell and bottom platform stiffeners: sea pressure and side shell impacts
- for deck and superstructure stiffeners: The greater value of sea pressures and minimum loads.
- for tank stiffeners: local internal pressure and testing loads
- for stiffeners on watertight bulkheads fitted for damage stability: flooding loads.

3.1.2 Ends stiffener conditions

The connection of secondary stiffeners with surrounding supporting structure is to be taken into account in the calculation of the rule stiffener section moduli.

The following three hypotheses on end stiffener conditions are taken into consideration in the scantling formulae, using a coefficient m equal, successively, to:

- for fixed end connection: m = 12

  The cross-section at the ends of the stiffener cannot rotate under the effect of the lateral loads. (As a rule, the secondary stiffeners are considered with fixed ends).

  The section modulus is to be checked at the ends of the stiffener.
- for simply supported end connection: m = 8

  The cross-section at the ends of the stiffener can rotate freely under the effect of the lateral loads.

  The section modulus is to be checked at mid span of the stiffener.
- for intermediate conditions: m=10

  The cross-section at the ends of the stiffener is in an intermediate condition between fixed end condition and simply supported end condition.

  The section modulus is to be checked at mid span of the stiffener.

3.1.3 Geometric properties

a) Geometric properties:

   The geometric properties of stiffeners (Inertia, modulus and shear section) are to be determined by direct calculation.

b) Attached plating for local load analysis:

   The width b_p of the attached plating to be considered for the calculation of the stiffener geometric properties is to be taken, in m, equal to:

   - where the plating extends on both sides of the secondary stiffener:

     $b_P = s$
   - where the plating extends on one side of the secondary stiffener (i.e. secondary stiffener bounding an opening):

     $b_P = 0{,}5s$

3.1.4 Bulb section

As a rule, the inertia, section modulus and shear section of bulb section of steel stiffener may be determined taking into account the following equivalent dimensions of an angle profile:

$$h_w = h'_w - \frac{h'_w}{9{,}2} + 2$$

$$t_w = t'_w$$

$$b_f = \alpha\left[t'_w + \frac{h'_w}{6{,}7} - 2\right]$$

$$t_f = \frac{h'_w}{9{,}2} - 2$$

where:

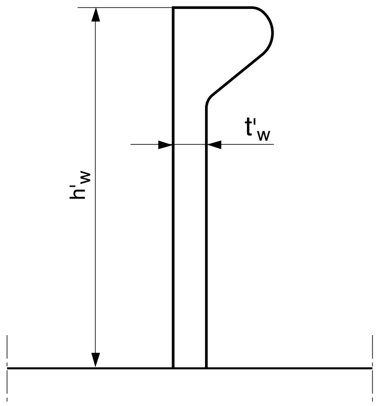
h'_w, t'_w : Height and thickness of the bulb section, in mm, as shown in Fig 1

α : Coefficient equal to:

$$1{,}1 + \frac{(120 - h'_w)^2}{3000} \quad \text{for } h'_w \le 120$$

$$1{,}0 \quad \text{for } h'_w > 120$$

Figure 1 : Dimensions of a steel bulb section



3.1.5 Span of stiffeners

The span ℓ of stiffeners is to be measured as shown in Fig 2 to Fig 4.

For open floors, when a beam calculation taking into account the rigidity of the two transverse stiffeners is not carried out, the span ℓ of transverse ordinary stiffeners connected by one or two struts is to be taken equal to $0,7\ell_2$ (see Fig 5).

Figure 2 : Stiffener with a stiffener at one end

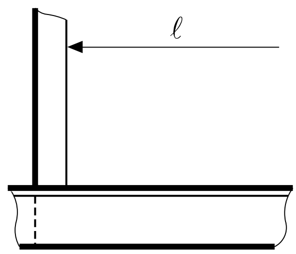


Figure 3 : Stiffener with end bracket

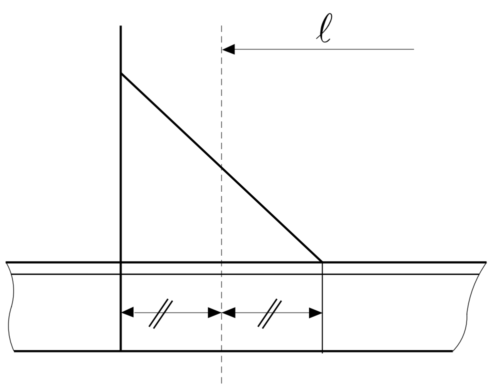


Figure 4 : Stiffener with a bracket and a stiffener at one end

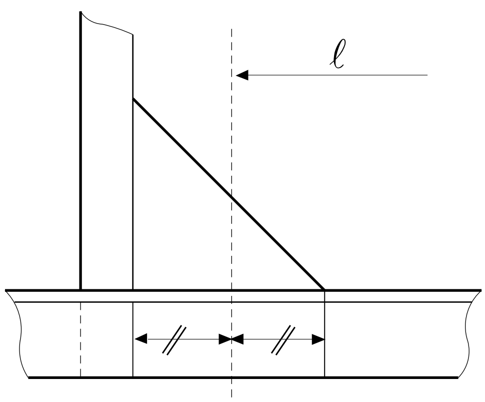


Figure 5 : Span of stiffener for open floors

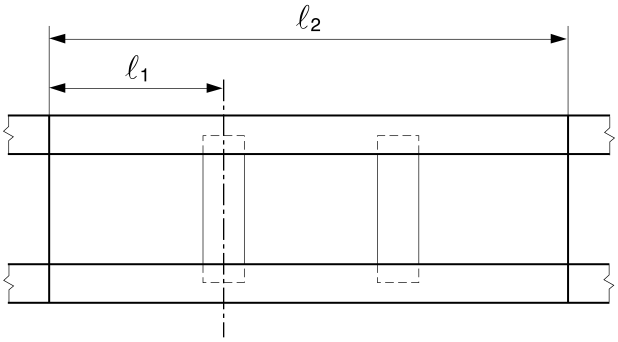
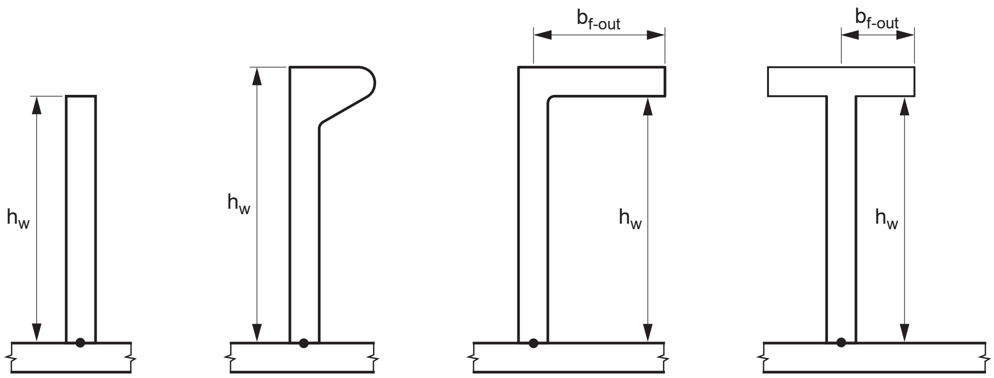


Figure 6 : Stiffener scantling parameters



3.2 Recommended proportions of secondary stiffeners

3.2.1 General

As a rule, the proportion of primary stiffeners are to be as defined in the present Sub-article. Other proportions may be considered if the buckling assessment under local loads and axial loads is carried out according to Ch 5, Sec 10.

3.2.2 Proportion of secondary stiffeners

As a rule, the thicknesses (web and flange) of stiffeners are to satisfy the following criteria:

a) Stiffener web plate:

$$t_w \geq \frac{h_w}{C_w} \sqrt{\frac{R_{eH}}{235}}$$

b) Stiffener flange:

$$t_f \geq \frac{b_{f\text{-out}}}{C_f} \sqrt{\frac{R_{eH}}{235}}$$

$b_f \geq 0{,}25\ h_w$

where:

h_w, t_w, $b_{f\text{-out}}$: Dimensions of the stiffener, in mm, as defined in Fig 6.

b_f : Total breath, in mm, of the flange.

t_p, t_w, t_f : Thickness, in mm, of the attached plating, web and flange

C_w, C_f : Slenderness coefficients given in Tab 1.

Table 1 : Slenderness coefficient

Type of stiffeners	C_w	C_f
Angle bars	75	12
T-bars	75	12
Bulb bars	45	–
Flat bars	22	–

3.3 Secondary stiffener scantling

3.3.1 Minimum section modulus

As a rule, the minimum section modulus, in cm^3, of hull and decks secondary stiffeners calculated according to the present Section are not to be less than:

- for steel secondary stiffener: 0,15 L_W k + 4
- for aluminium secondary stiffener: 2 $L_W^{1/3}$ k

where:

L_w : $L_w = 0{,}5\ (L_{WL} + L_{HULL})$

k : Material factor defined in Ch 5, Sec 1.

3.3.2 Secondary stiffener under sea pressure

As a rule, the section modulus Z, in cm^3, and the shear area A_{sh}, in cm^2, of the secondary stiffeners sustaining lateral local pressure are to be not less than the values obtained by the following formula:

- for longitudinal stiffeners and transverse deck stiffeners:

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

$$A_{sh} = 5 \cdot C_t \cdot \lambda \cdot \frac{p \cdot s \cdot \ell}{\tau_{locam}}$$

- for vertical transversal stiffeners:

$$Z = 1000\lambda C_f \frac{p_1 s \ell^2}{m_b \sigma_{locam}}$$

$$A_{sh} = 10\lambda C_t \frac{p_2 s \ell}{m_s \tau_{locam}}$$

where:

p_1, p_2 : Equivalent pressure, in kN/m^2, as defined in Tab 2

m_b, m_s : End stiffener condition coefficients defined in Tab 2

where:

λ : Corrosion coefficient taken equal to:

For stiffener located in superstructure and roof:

- for steel stiffener: 1,05
- for aluminium stiffener: 1,0

In other cases:

- for steel structure:
  - for stiffener located in a dry compartment: λ = 1,1
  - for stiffener located in a liquid compartment: λ = 1,2
- for aluminium structure: λ = 1,05

C_f and C_t: Reduction coefficients to be taken equal to:

$$C_f = 1{,}0 - 0{,}25\left(\frac{s}{\ell}\right)^2 - 0{,}20\left(\frac{s}{\ell}\right)$$

$$C_t = 1 - \frac{s}{2\ell}$$

with C_f and C_t to be taken greater than 0,55 and 0,5 respectively

s : Spacing, in m, of the secondary stiffeners

ℓ : Span, in m, of the secondary stiffeners

m : End stiffener condition coefficient defined in [3.1.2]

m_b, m_s : End stiffener condition coefficients defined in Tab 2

σ_{locam}, τ_{locam}: Local permissible stresses, in N/mm^2, as defined in Ch 5, Sec 3, [2.2], for local sea pressure

p : Local sea pressures or internal pressures, in kN/m^2, as defined in Ch 4, Sec 3, [2.1] and Ch 4, Sec 4.

3.3.3 Secondary stiffener under bottom slamming

As a rule, the section modulus Z, in cm^3, and the shear area A_{sh}, in cm^2, of the secondary stiffeners sustaining lateral bottom slamming pressure are to calculated as defined in [3.3.2] for horizontal stiffener, with:

p : Local bottom slamming pressure, in kN/m^2, to be taken equal to P_{sl} as defined in Ch 4, Sec 3, [3.2.2]

C_t, C_f : Reduction coefficient to be taken equal to 1

σ_{locam}, τ_{locam}: Local permissible stresses, in N/mm^2, as defined in Ch 5, Sec 3, [2.2], for local dynamic pressure.

Table 2 : Equivalent pressures

End stiffener condition	P_1	m_b	P_2	m_s
Both ends fixed	$2\ p_{Supper} + 3\ p_{Slower}$	60	$3\ p_{Supper} + 7\ p_{Slower}$	20
Lower end fixed, upper end supported	$7\ p_{Supper} + 8\ p_{Slower}$	120	$9\ p_{Supper} + 16\ p_{Slower}$	40
Both ends supported	$p_{Supper} + p_{Slower}$	16	$p_{Supper} + 2\ p_{Slower}$	6
Note 1: p_{slower}, p_{supper}: Local sea pressures or internal pressures, in kN/m², as defined in Ch 4, Sec 3, [2.1] and Ch 4, Sec 4 and calculated respectively at the lower end and the upper end of the stiffener.				

3.3.4 Secondary stiffener under side shell impact

As a rule, the section modulus Z, in cm³, and the shear area A_{sh}, in cm², of the secondary stiffeners sustaining lateral side shell impacts are to be not less than the values obtained by the following formula:

$$Z = 1000\lambda C_{fs}\frac{Ps\ell^2}{m\sigma_{locam}}$$

$$A_{sh} = 5\lambda C_{ts}\frac{Ps\ell}{\tau_{locam}}$$

where:

λ, ℓ, s, m: As defined in [3.3.2]

C_{fs} : Reduction coefficient equal to: $(3\ell^2 - 0,36)\cdot 0,3/\ell^3$ with $\ell \geq 0,6$ m

C_{ts} : Reduction coefficient equal to: $0,6/\ell$,without being taken greater than 1.

σ_{locam}, τ_{locam}: Local permissible stresses, in N/mm², as defined in Ch 5, Sec 3, [2.2], for local dynamic pressure

P : Pressure, in KN/m², to be taken equal to: $P = C_p\ P_{ssmin}$

C_p : Pressure coefficient equal to: $C_p = -0,98s^2 + 0,3s + 0,95 \geq 0,8$

p_{ssmin} : Local impact pressure on side shell at platform bottom of catamaran, in kN/m², as defined in Ch 4, Sec 3, [3.1].

The present requirement is also applicable for the scantling check of stiffeners located in the lowest tier of sidewalls of superstructure and bulwarks in prolongation of the side shell.

4 Primary stiffener scantling

4.1 General

4.1.1 Loading cases

Scantlings of primary stiffeners are to be checked under the following loading cases:

- for bottom primary stiffeners: wave loads and bottom slamming pressure (when slamming may occur)
- for side shell primary stiffeners: sea pressures
- for deck and superstructure primary stiffeners: the greater value of sea pressures and minimum loads.

4.1.2 Primary floating frame

As a rule, this type of floating frame are to be examined on a case by case basis taking into account the arrangement of the collar plates between the web stiffener and the attached plating to assess the efficiency of the attached plating.

4.1.3 Geometric properties

a) Geometric properties:

   The geometric properties of stiffeners (Inertia, modulus at flange and associated plate and shear section) are to be determined by direct calculation.

b) Attached plating for local load analysis:

   The width b_p of the attached plating to be considered for the calculation of the stiffener geometric properties is to be taken, in m, equal to:

   - where the plating extends on both sides of the primary stiffener:

     $b_P = \min (s; 0,2\ell)$

   - where the plating extends on one side of the primary stiffener (i.e. primary stiffener bounding an opening):

     $b_P = 0,5 \min (s; 0,2\ell)$

4.2 Recommended proportions of primary stiffeners

4.2.1 General

As a rule, the proportion of primary stiffeners are to be as defined in the present Sub-article. Other proportions may be considered if the buckling assessment under local loads and axial loads is carried out according to Ch 5, Sec 10.

4.2.2 Proportions of primary stiffeners

As a rule, the thicknesses (web and flange) of stiffeners are to satisfy the following criteria:

$$t_w \geq \frac{s_w}{100}\sqrt{\frac{R_{eH}}{235}}$$

$$t_f \geq \frac{b_{f\text{-}out}}{C_f}\sqrt{\frac{R_{eH}}{235}}$$

where:

s_w : Plate breadth, in mm, taken as the spacing of the web stiffeners

t_w, t_f : Thickness, in mm, of the and flange

C_f : Slenderness coefficients to be taken equal to 12.

4.3 Structural beam models

4.3.1 isolated beam model

a) General

The present requirements for the scantling of primary stiffeners apply for isolated beam calculation.

b) Scantling

The primary stiffener scantling is to be checked as defined for the secondary stiffener in [3], excepted otherwise specified, considering successively the different loads sustained by the primary stiffener defined in [4.1.1] and the relevant permissible stresses defined in Ch 5, Sec 3.

The following parameter is to be taken into account in the section modulus and shear area formula:

- Reduction coefficient $C_t = C_f = 1$

c) Scantling of primary stiffeners on deck exposed to sea pressure

For the primary stiffeners on deck exposed to sea pressure, the section modulus Z and shear area A_{sh}, can be reduced by the following coefficients:

- 0,8 for primary structure of exposed superstructure decks
- $(1 - 0,05\ \ell) > 0,8$ for primary structure of exposed decks.

d) Buckling of attached plating

Depending on the compression stress level in the attached plating induced by the bending of primary stiffener under the local loads, it may be necessary to check the buckling of the attached plating along the primary stiffener span.

The buckling of the attached plating is to be checked according to the criteria defined in Ch 5, Sec 10, [2.4.7].

e) Curvate primary stiffeners

The curvature of primary supporting members may be taken into account by direct analysis.

In case of 2-D or 3-D beam structural model, the curved primary supporting members are to be represented by a number N of straight beams, N being adequately selected to minimize the spring effect in way of knuckles.

The stiffness of knuckles equivalent springs is considered as minor from the local bending moment and shear forces distribution point of view where the angle between two successive beams is not more than 3°.

f) Large opening on primary stiffeners

In case of large openings on primary stiffeners, the secondary stresses are to be determined as defined in [4.3.3].

The local permissible stresses in way of the large opening are to be as defined in Ch 5, Sec 3, depending on the type of load.

4.3.2 Two or three dimensional beam model

When an isolated beam calculation of the primary structure is not possible due to an interaction of the primary stiffeners, a two or three dimensional structural model analysis including the different primary stiffeners is to be carried out as follows:

a) Model:

The structural model is to represent the primary supporting members of the structure area considered.

The extension of the structural model is to be such that the results in the areas to be analysed are not influenced by the unavoidable inaccuracy in the modelling of the boundary conditions.

b) Loading conditions:

The local lateral pressures to be considered are:

- for bottom primary stiffeners: sea pressures and bottom slamming pressures (when slamming may occur)
- for side shell and, for multihull, primary transverse cross structure of platform bottom: sea pressures (without taking into account side shell impact)
- for deck primary stiffeners: external or minimum loads and,
- for all primary stiffeners, when applicable: internal pressures.

Note 1: When a bottom slamming pressure analysis is carried out, the impact pressure p_{sl} defined in Ch 4, Sec 3, [3.2] is to be only applied on one floor of the model as a constant pressure. The other floors of the model are to be loaded by the bottom sea pressure.

c) Local load point calculation:

The location of the point of the stiffener where the local loads are to be calculated in order to check the scantling are defined in [1.3].

d) Checking criteria:

It is to be checked that the equivalent stresses σ_{VM} deduced from the model are in compliance with Ch 5, Sec 3.

4.3.3 Cut-outs and large openings

a) General:

In case of large openings as shown in Fig 7, the secondary stresses in primary supporting members are to be considered for the reinforcement of the openings, where deemed necessary.

b) Cut-outs in web:

Cut-outs for the passage of ordinary stiffeners are to be as small as possible and well rounded with smooth edges.

In general, the height of cut-outs is to be not greater than 50% of the height of the primary supporting member.

c) Location of cut-outs in web:

As a general rules, where openings such as lightening holes or duct routing for pipes, electrical cable,..., are cut in primary supporting members, they are to be equidistant from the face plate and the attached plate. Their height is not to be more than 20% of the primary supporting member web height.

The length of the openings is to be not greater than:

- at the end of primary member span: 25% of the distance between adjacent openings
- elsewhere: the distance between adjacent openings.

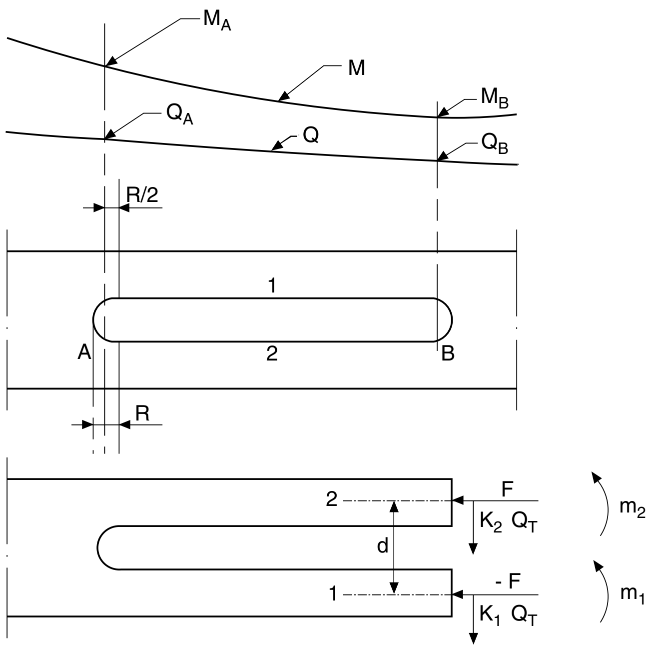
Openings may not be fitted in way of toes of end brackets.

d) Large openings:

In case of large openings as shown in Fig 7, the secondary stresses in primary supporting members are to be considered for the reinforcement of the openings, where deemed necessary.

The secondary stresses may be calculated in accordance with the following procedure.

Figure 7 : Large openings in primary supporting members - Secondary stresses



Members (1) and (2) are subjected to the following forces, moments and stresses:

$$F = \frac{M_A + M_B}{2d}$$

$$m_1 = \left|\frac{M_A - M_B}{2}\right| K_1$$

$$m_2 = \left|\frac{M_A - M_B}{2}\right| K_2$$

$$\sigma_{F1} = 10\frac{F}{S_1}$$

$$\sigma_{F2} = 10\frac{F}{S_2}$$

$$\sigma_{m1} = \frac{m_1}{w_1}10^3$$

$$\sigma_{m2} = \frac{m_2}{w_2}10^3$$

$$\tau_1 = 10\frac{K_1 Q_T}{S_{w1}}$$

$$\tau_2 = 10\frac{K_2 Q_T}{S_{w2}}$$

where:

M_A, M_B : Bending moments, in kN.m, in sections A and B of the primary supporting member

m_1, m_2 : Bending moments, in kN.m, in (1) and (2)

d : Distance, in m, between the neutral axes of (1) and (2)

σ_{F1}, σ_{F2} : Axial stresses, in N/mm², in (1) and (2)

σ_{m1}, σ_{m2} : Bending stresses, in N/mm², in (1) and (2)

Q_T : Shear force, in kN, equal to Q_A or Q_B, whichever is greater

τ_1, τ_2 : Shear stresses, in N/mm², in (1) and (2)

w_1, w_2 : Net section moduli, in cm³, of (1) and (2)

S_1, S_2 : Net sectional areas, in cm², of (1) and (2)

S_{w1}, S_{w2} : Net sectional areas, in cm², of webs in (1) and (2)

I_1, I_2 : Net moments of inertia, in cm⁴, of (1) and (2) with attached plating

$$K_1 = \frac{I_1}{I_1 + I_2}$$

$$K_2 = \frac{I_2}{I_1 + I_2}$$

The combined stress σ_C calculated at the ends of members (1) and (2) is to be obtained from the following formula:

$$\sigma_c = \sqrt{(\sigma_F + \sigma_m)^2 + 3\tau^2}$$

The combined stress σ_C is to comply with the checking criteria defined in Ch 5, Sec 3. Where these checking criteria are not complied with, the cut-out is to be reinforced according to one of the solutions shown in Fig 8 to Fig 10:

- continuous face plate (solution 1): see Fig 8
- straight face plate (solution 2): see Fig 9
- compensation of the opening (solution 3) by increase of the web thickness t_1: see Fig 10

Other arrangements may be accepted provided they are supported by direct calculations submitted to the Society for review.

Figure 8 : Solution 1

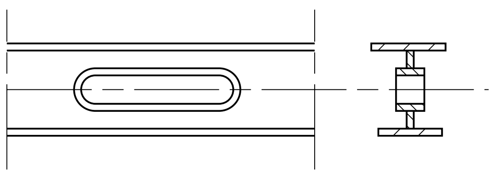


Figure 9 : Solution 2

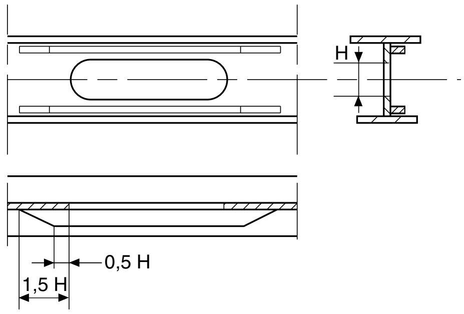
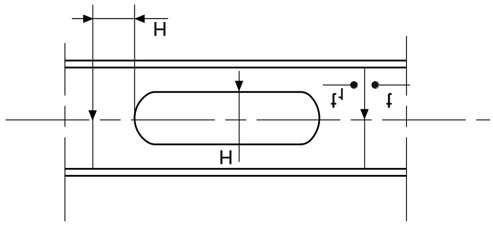


Figure 10 : Solution 3



4.4 Finite element model

4.4.1 General

This Sub-article is a guidance for the stress check (maximum and buckling stresses) of primary structure loaded under local loads only using a finite element model.

4.4.2 Finite elements

In order to obtain an accurate representation of stresses in the areas of interest, the structural model is to be built on the basis of the following criteria:

- the mesh dimensions are to be such as to enable a faithful representation of the stress gradients
- quadrilateral elements are to have 90° angles as much as possible, or angles between 60° and 120°
- the use of linear triangular elements is to be avoided as much as possible in high stress area. When the use of a linear triangular element cannot be avoided, its edges are to have the same length
- the use of membrane and rod elements is only allowed when significant bending effects are not present; in the other cases, elements with general behaviour (quadratic finite element acting in traction, compression and bending and bar element acting also in bending) are to be used
- webs of primary members are to be modelled with at least three elements on their height
- the ratio between the longer side and the shorter side of elements is to be less than 3 in the areas expected to be highly stressed.
- large openings in web of primary supporting members and door openings in bulkheads are to be correctly represented taking into account local reinforcement when provided.

4.4.3 Loads and boundary conditions

a) Loads:

The finite element model is to be loaded taking into account the local loads defined in Ch 4, Sec 3 and Ch 4, Sec 4.

Distributed loads are to be applied:

- to the plating panels when the platings are modelled by shell elements (quadratic finite element acting in traction, compression and bending) and the secondary stiffeners by bar elements (acting also in bending), or
- directly to the primary supporting members actually supporting the secondary stiffeners proportionally to the areas of influence of secondary stiffeners.

b) Boundary conditions:

The finite element calculation is to be performed with displacement restrictions applied to nodes of the model. Rotations of these nodes are to be free.

As a rule, these nodes are to be located outside the model areas where stress checks are carried out.

Detailed justifications may be requested by the Society to verify that the forces reactions applied to these nodes do not affect the bending moments and shear forces applied to the model.

4.4.4 Stress check

a) Stress components:

Stress components are generally identified with respect to the element co-ordinate system. The orientation of the element co-ordinate system in relation to the reference co-ordinate system of the model is to be specified.

The following stress components to be considered and calculated at the centroid of each element are:

- the normal stresses σ_1 and σ_2 in the directions of element co-ordinate system axes
- the shear stress τ_{12} with respect to the element co-ordinate system axes

b) Stress check:

The maximum stresses and buckling stresses are to be calculated as follow:

- Maximum stress check:

  The Von Mises equivalent stress, σ_{eq}, in N/mm², is to be derived as follows:

$$\sigma_{eq} = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2 + 3\tau_{12}^2}$$

  Where σ_1, σ_2 and τ_{12} are defined in a).

- Buckling stress check:

  Where the buckling panel is meshed by several finite plate elements, the stresses of the buckling panel are obtained by the following methodology:

  - For each plate finite element, the stresses ($\sigma_{\xi\,\varepsilon}{}^*$, $\sigma_{\psi\,\varepsilon}{}^*$, $\tau_\varepsilon{}^*$) expressed in the element co-ordinate system are projected in the co-ordinate system of the buckling panel to obtained the stresses ($\sigma_{\xi\,\varepsilon}$, $\sigma_{\psi\,\varepsilon}$, τ_ε).
  - For the buckling panel, the stresses are calculated according to the following formula:

$$\sigma_x = \frac{\sum_i^n A_i \sigma_{x\,e_i}}{\sum_i^n A_i} \geq 0$$

$$\sigma_y = \frac{\sum_i^n A_i \sigma_{y\,e_i}}{\sum_i^n A_i} \geq 0$$

$$\tau = \frac{\sum_i^n A_i \tau_{e_i}}{\sum_i^n A_i} \geq 0$$

  where:

  $\sigma_{\xi\,\varepsilon\iota}$, $\sigma_{\psi\,\varepsilon\iota}$: Stresses, in N/mm², of the plate finite element i, taken equal to 0 in case of tensile stress

  τ_{ei} : Shear stress, in N/mm², of the plate finite element i

  A_i : Area, in mm², of the plate finite element i.

- Scantling criteria:

  The maximum actual stresses and buckling stresses are to fulfill the permissible global stresses and buckling safety factors defined in Ch 5, Sec 3, Tab 2 taking into account Ch 5, Sec 3, [2.3].

Section 6 Stiffener Brackets Scantling

1 General arrangement of brackets

1.1 Materials

1.1.1 The requirements of the present section are applicable to yacht hulls made totally or partly of steel materials.

For yacht hulls built of aluminium alloys, the requirements to apply are defined in NR561 Hull in Aluminium Alloys, Section 6.

1.2 General requirements

1.2.1 As a general rules, brackets are to be provided at the stiffener ends when the continuity of the web and the flange of the stiffeners is not ensured in way of their supports.

1.2.2 Arm lengths of end brackets are to be equal, as far as practicable.

1.2.3 The section of the end bracket web is generally to be not less than that of the supported stiffener.

1.2.4 The section modulus of the end bracket is to be at least equal to the section modulus of the stiffener supported by the bracket.

When the bracket is flanged, the section modulus is to be examined in way of flange as well as in way of the end of the flange.

1.2.5 Bracket flanges

Steel brackets having a thickness, in mm, less than $16,5L_b$ are to be flanged or stiffened by a welded face plate, such that:

- the sectional area, in cm², of the flanged edge or the face plate is at least equal to $10L_b$
- the thickness of the bracket flange is not less than that of the bracket web.

where:

L_b : length, in m, of the free edge of the bracket.

1.2.6 When a face plate is welded on end brackets to be strengthened, this face plate is to be symmetrical.

In such a case, the following arrangements are to be complied with, as a rule:

- the face plates are to be snipped at the ends, with total angle not greater than 30°
- the width of the face plates at ends is not to exceed 25 mm
- the face plates being 20 mm thick or above are to be tapered at ends over half the thickness
- the radius of the curved face plate is to be as large as possible
- a collar plate is to be fitted in way of bracket toes
- the fillet weld throat thickness is to be not less than t/2, where t is the thickness at the bracket toe.

2 Bracket for connection of perpendicular stiffeners

2.1 General arrangement

2.1.1 Typical bracket for connection of perpendicular stiffeners are shown from Fig 1 to Fig 6.

As a general rules, brackets are to be in accordance with the requirements defined in [1.2].

Where no direct calculation is carried out, the minimum length d, in mm, as defined from Fig 1 to Fig 6 may be taken equal to:

$$d = \varphi \sqrt{\frac{w + 30}{t}}$$

where:

φ : Coefficient equal to:

- for unflanged brackets: $\varphi = 48,0$
- for flanged brackets: $\varphi = 43,5$

w : Required section modulus of the supported stiffener, in cm³

t : Bracket thickness, in mm.

When a bracket is provided to ensure the simultaneous continuity of two (or three) stiffeners of equivalent stiffness, the bracket scantling is to be examined by direct calculation, taking into account the balanced bending moment in the connection of the two (or three) stiffeners.

Figure 1 : Bracket at upper end of ordinary stiffener on plane bulkhead

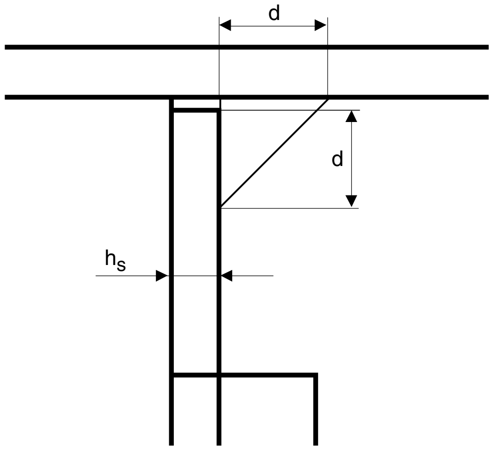


Figure 2 : Bracket at lower end of ordinary stiffener on plane bulkhead

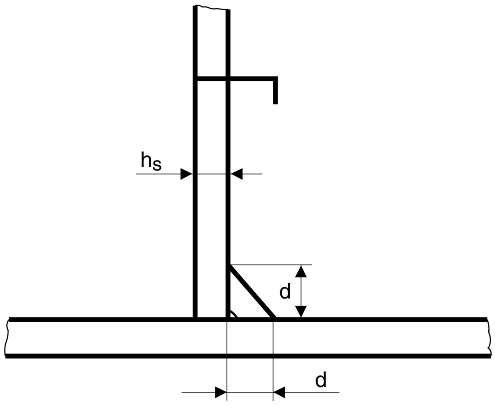
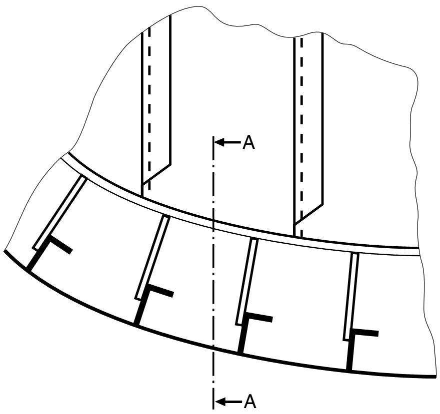
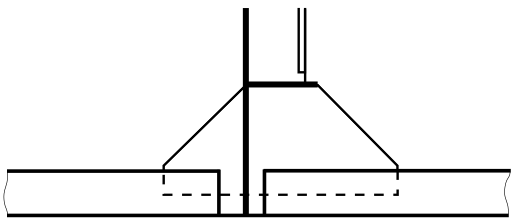


Figure 3 : Other bracket arrangement at lower end of secondary stiffeners on plane bulkhead





Section A-A

Figure 4 : Connections of perpendicular stiffeners in the same plane

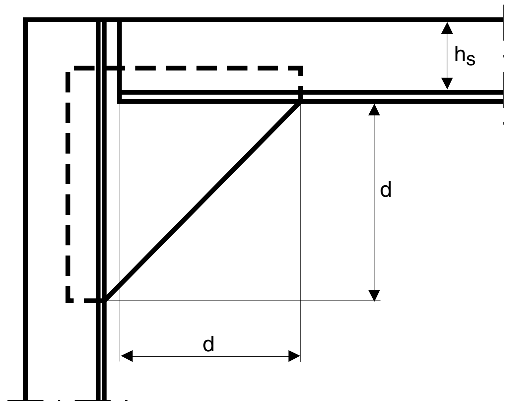


Figure 5 : Connections of stiffeners located in perpendicular planes

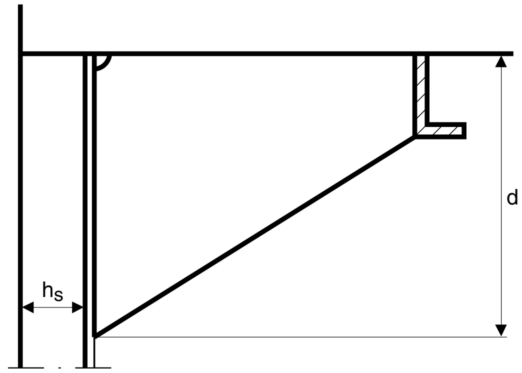
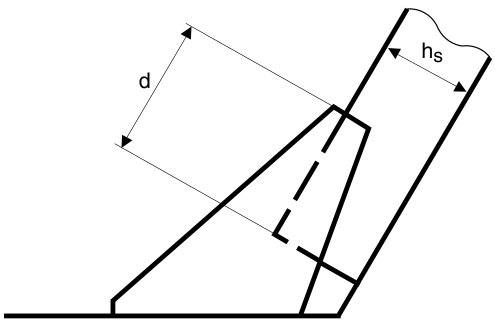


Figure 6 : Lower brackets of main frames



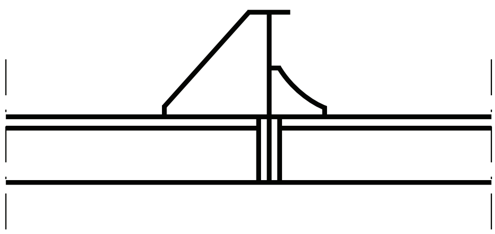
3 Brackets ensuring continuity of secondary stiffeners

3.1 General

3.1.1 Where secondary stiffeners are cut in way of primary supporting members, brackets (or equivalent arrangements) are to be fitted to ensure the structural continuity as defined in Fig 7, or equivalent. Their section moduli and their sectional area are to be not less than those of the secondary stiffeners.

Equivalent arrangement may be considered on a case-by-case basis.

Figure 7 : End connection of ordinary stiffener - Backing bracket



4 Bracketless end stiffeners connections

4.1 Bracketless end connections

4.1.1 General

The design of bracketless connections is to be such as to provide adequate resistance to rotation and displacement connection.

4.1.2 Case of two stiffeners

In the case of bracketless crossing between two primary supporting members (see Fig 8), the thickness t_b of the common part of the webs, in mm, is to be not less than the greater value obtained from the following formula:

$$t_b = \frac{Sf_1 \sigma_1}{0,4 h_2 R_y}$$

$$t_b = \frac{Sf_2 \sigma_2}{0,4 h_1 R_y}$$

$$t_b = \max(t_1, t_2)$$

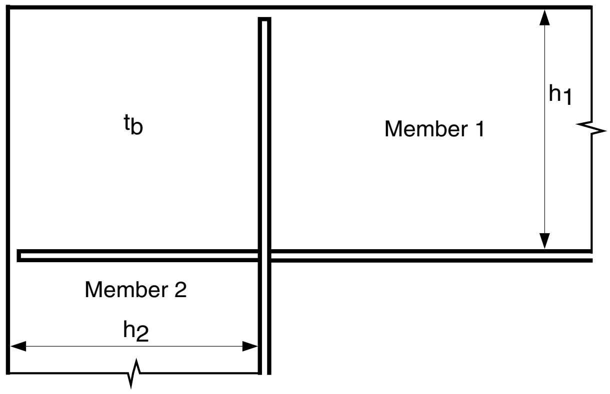
where:

Sf_1, Sf_2 : Flange sections, in mm²,of member 1 and member 2 respectively

σ_1, σ_2 : Normal stresses, in N/mm², in member 1 and member 2 respectively

R_y : Minimum guaranteed yield stress in N/m², defined in Ch 5, Sec 1, [3.1.5]

Figure 8 : Bracketless end connections between two primary supporting members



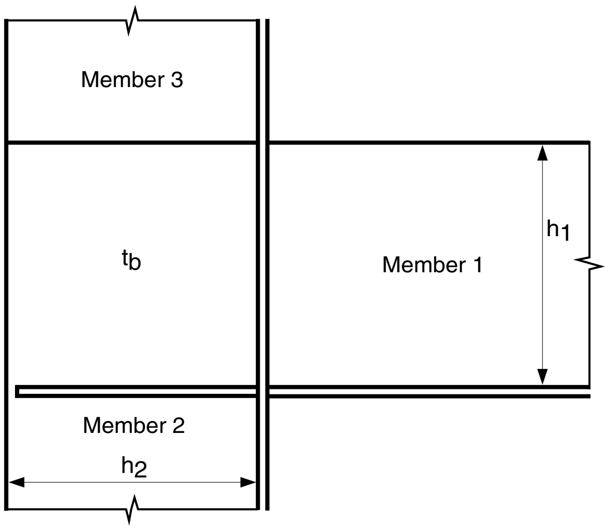
4.1.3 Case of three stiffeners

In the case of bracketless crossing between three primary supporting members (see Fig 9), and when the flange continuity is ensured between member 2 and member 3, the thickness t_b of the common part of the webs, in mm, is to be not less than:

$$t_b = \frac{Sf_1 \sigma_1}{0,4 h_2 R_y}$$

When the flanges of member 2 and member 3 are not continuous, the net thickness of the common part of the webs is to be defined as [4.1.2].

Figure 9 : Bracketless end connections between three primary supporting members



4.1.4 Stiffening of common part of webs

When the minimum value of heights h_1 and h_2 of the member 1 and member 2 is greater than $100t_b$, the common part of the webs is generally to be stiffened.

4.1.5 Lamellar tearing in way of flanges

When lamellar tearing of flanges is likely to occur, a 100% ultrasonic testing of the flanges in way of the weld may be required after welding.

4.2 Other type of end connection

4.2.1 Where end connections are made according to Fig 10, a stiffener with sniped ends is to be fitted on connection web, when:

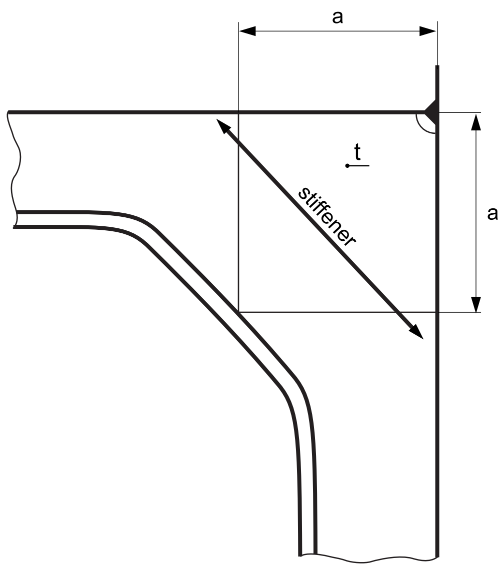
$a > 100\,t$

where:

a : Dimension, in mm, measured as shown on Fig 10

t : Web thickness, in mm.

Figure 10 : End connection with stiffener



Section 7 Joint Design and Weld Scantling for Steel and Aluminium

1 General

1.1 Materials

1.1.1 The requirements of the present Section apply to the scantling and joint design of welded connection of yachts built in steel materials.

The equivalent requirements for yachts built in aluminium alloys are to be in accordance with NR561 Hull in Aluminium Alloys.

The conditions for heterogeneous assembly between steel and aluminium structures are to be as defined in NR561 Hull in Aluminium Alloys, Section 3.

1.2 Application

1.2.1 The scantling and preparation for the welding of steel hull structure are to be as defined in the present Section.

Other equivalent standards may be accepted by the Society, on a case-by-case basis.

The general requirements relevant to the execution of welding, inspection and qualification of welding procedures are given in Ch 5, Sec 11 and in NR216 Rules on Materials and Welding, Chapter 12.

1.2.2 Welding of various types of steel is to be carried out by means of welding procedures approved for the purpose.

1.2.3 Weld connections are to be executed according to:

- the approved hull construction plans, and
- the weld and welding booklets submitted to the Society.

Any details not specifically represented in the plans are, in any case, to comply with the applicable requirements of the Society.

1.2.4 The method used to prepare the parts to be welded is left to the discretion of each shipbuilder, according to its own technology and experience.

These methods are to be reviewed during the qualification of welding procedure, as defined in [1.3.2].

1.3 Weld and welding booklet

1.3.1 Weld booklet

A weld booklet, including the weld scantling such as throat thickness, pitch and design of joint, is to be submitted to the Society for examination.

The weld booklet is not required if the structure drawings submitted to the Society contain the necessary relevant data defining the weld scantling.

1.3.2 Welding booklet

A welding booklet including the welding procedures, operations, inspections and the modifications and repair during construction as defined in Ch 5, Sec 11, [3] is to be submitted to the Surveyor for examination.

2 Scantling of welds

2.1 Butt welds

2.1.1 As a rule, butt welding is to be used for plate and stiffener butts and is mandatory for heavily stressed butts such as those of the bottom, keel, side shell, sheerstrake and strength deck plating, and bulkheads (in particular bulkheads located in areas where vibrations occur).

2.1.2 As a rule, all structural butt joints are to be full penetration welds completed by a backing run weld.

2.2 Butt welds on permanent backing

2.2.1 Butt welding on permanent backing may be accepted where a backing run is not feasible.

In this case, the type of bevel and the gap between the members to be assembled are to be such as to ensure a proper penetration of the weld on its backing.

2.3 Fillet weld on a lap-joint

2.3.1 General

Fillet weld in a lap joint may be used only for members submitted to moderate stresses, taking into account the typical details shown on Tab 1.

Continuous welding is generally to be adopted.

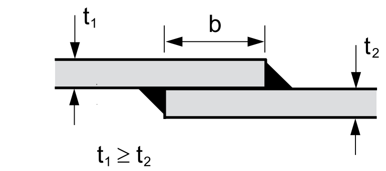
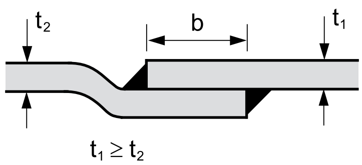
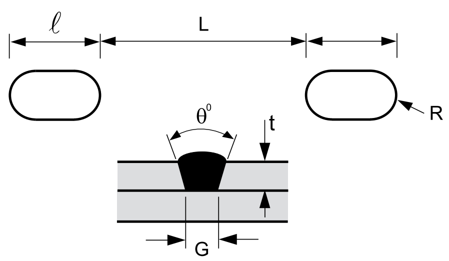
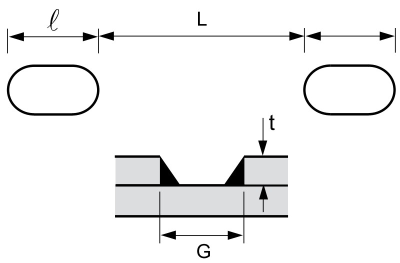
2.3.2 The surfaces of lap-joints are to be in sufficiently close contact.

2.4 Slot welds

2.4.1 Slot welds may be used where fillet welding is not possible.

Slot weld is, in general, permitted only where stresses act in a predominant direction. Slot welds are, as far as possible, to be aligned in this direction.

Table 1 : Typical lap joint, plug and slot welds (manual welding)

Detail	Standard		Remark
Fillet weld in lap joint  	$b = 2\ t_2 + 25$ mm		location of lap joint to be approved by the Society
Fillet weld in joggled lap joint  	$b \geq 2\ t_2 + 25$ mm		
Plug weld  	• $t \leq 12$ mm $\ell = 60$ mm $R = 6$ mm $40° \leq \theta \leq 50°$ $G = 12$ mm $L > 2\ \ell$	• 12 mm $< t \leq 25$ mm $\ell = 80$ mm $R = 0{,}5\ t$ mm $\theta = 30°$ $G = t$ mm $L > 2\ \ell$	
Slot weld  	• $t \leq 12$ mm $G = 20$ mm $\ell = 80$ mm $2\ \ell \leq L \leq 3\ \ell$, max 250 mm	• $t > 12$ mm $G = 2\ t$ $\ell = 100$ mm $2\ \ell \leq L \leq 3\ \ell$, max 250 mm	

2.4.2 Slot welds are to be of appropriate shape (in general oval) and dimensions, depending on the plate thickness, and may not be completely filled by the weld (see Tab 1).

The distance between two consecutive slot welds is to be not greater than a value which is defined on a case by case basis taking into account:

- the transverse spacing between adjacent slot weld lines
- the stresses acting in the connected plates
- the structural arrangement below the connected plates.

2.5 Plug welds

2.5.1 Plug welds may be adopted exceptionally as a substitute to slot welding.

Typical details are given in Tab 1.

2.6 Fillet welds

2.6.1 Fillet welding types

Fillet welds may be of the following types:

- continuous fillet weld, where the weld is constituted by a continuous fillet on each side of the abutting plate
- intermittent fillet weld, which may be subdivided into:
  - chain welding
  - staggered welding.

2.6.2 Double continuous fillet weld location

As a general rule, double continuous fillet weld is to be required in the following locations, as appropriate:

- watertight and oiltight connections
- main engine and auxiliary machinery seatings
- bottom structure of planing hull in way of jet room spaces
- structure in way of bilge keel, stabiliser, bow thruster, cranes
- bottom structure in the vicinity of propeller blade
- primary and secondary stiffeners in way of end supports (crosstie, pillars, brackets) and knees on a length extending over the depth of the stiffener and at least equal to 75 mm for:
  - web stiffener connection with the attached plating
  - flange stiffener with web of built-up stiffeners
- stiffeners in tanks intended for the carriage of ballast or fresh water.
- structure in way of bilge keel, stabilizer, bow thruster, cranes,...

Continuous fillet weld may also be adopted in lieu of intermittent welding wherever deemed suitable, and it is recommended where the length p, defined according to [2.6.5], is low.

Where direct calculations according to [2.6.4] or equivalent are carried out, discontinuous fillet weld may be considered on a case-by-case basis.

2.6.3 Throat thickness of double continuous fillet weld

The minimum throat thickness t_T of a double continuous fillet weld, in mm, is to be obtained from the following formula:

$$t_T = w_F t \geq t_{Tmin}$$

where:

w_F : Welding factor for the various hull structural elements, defined in Tab 2

t : Actual thickness, in mm, of the thinner plate of the assembly

t_{Tmin} : Minimum throat thickness, in mm, taken equal to:

- 3,0 mm, where the thickness of the thinner plate is less than 6 mm
- 3,5 mm, otherwise.

Note 1: A lower value of t_{Tmin} may be accepted on a case by case basis depending on the results of structural analyses.

The throat thickness t_T may be increased for particular loading conditions.

When fillet welding is carried out with automatic welding procedures, the throat thickness t_T may be reduced up to 15%, depending on the properties of the electrodes and consumables. However, this reduction may not be greater than 1,5 mm.

The same reduction applies also for semi-automatic procedures where the welding is carried out in downhand position.

Table 2 : Welding factor w_F for the various hull structural connections

Hull area	Connection			w_F **(1)**
	of	to		
General, unless otherwise specified in the Table	watertight plates	boundaries		0,35
	non-tight plates	boundaries		0,20
	strength decks	side shell		0,45
	webs of ordinary stiffeners	plating		0,13
		plating at ends **(2)**		0,20
		web of primary stiffener		see [2.6.7]
	web of primary stiffeners	plating and flange		0,20
		plating and flange at ends **(2)**		0,30 **(3)**
		bottom and inner bottom (in way of transversal and/or longitudinal bulkhead supported on tank top)		0,45
		deck (for cantilever deck beam)		0,45
		web of primary stiffeners		0,35
Structures located forward of 0,75 L from the aft end	ordinary stiffeners	bottom and side shell plating		0,20
	primary stiffeners	bottom, inner bottom and side shell plating		0,25
Structures located in bottom slamming area or in the first third of platform bottom of catamaran	ordinary stiffeners	bottom plating		0,20
	primary stiffeners	bottom plating		0,25
Machinery space	girders	bottom and inner bottom plating	in way of main engine foundations	0,45
			in way of seating of auxiliary machinery	0,35
			elsewhere	0,25
	floors (except in way of main engine foundations)	bottom and inner bottom plating	in way of seating of auxiliary machinery	0,35
			elsewhere	0,25
	floors in way of main engine foundations	bottom plating		0,35
		foundation plates		0,45
	floors	centre girder	single bottom	0,45
			double bottom	0,25
Superstructures and deckhouses	external bulkheads	deck		0,35
	internal bulkheads	deck		0,13
	ordinary stiffeners	external and internal bulkhead plating		0,13
Pillars	pillars	deck	pillars in compression	0,35
			pillars in tension	full penetration welding
Rudders	primary element directly connected to solid parts or rudder stock	solid part or rudder stock		0,45
	other webs	each other		0,20
	webs	plating	in general	0,20
			top and bottom plates of rudder plating	0,35

(1) For connections where $w_F \geq 0{,}35$, continuous fillet welding is to be adopted.

(2) The web at the end of intermittently welded stiffeners is to be continuously welded to the plating or the flange plate, as applicable, over a distance d at least equal to:

- For secondary stiffeners:
  - general: the depth h of the stiffeners, with 300 mm ≥ d ≥ 75 mm. Where end brackets are fitted, ends means the area extended in way of brackets and at least 50 mm beyond the bracket toes
  - floors: 20% of the span from span ends
  - bulkhead stiffeners: 25% of the span from span ends
- For primary stiffeners:
  Ends of primary supporting members means the area extended 20% of the span from the span ends. Where end brackets are fitted, ends means the area extended in way of brackets and at least 100 mm beyond the bracket toes.

(3) Full penetration welding may be required, depending on the structural design and loads.

2.6.4 Direct calculation of double continuous fillet weld

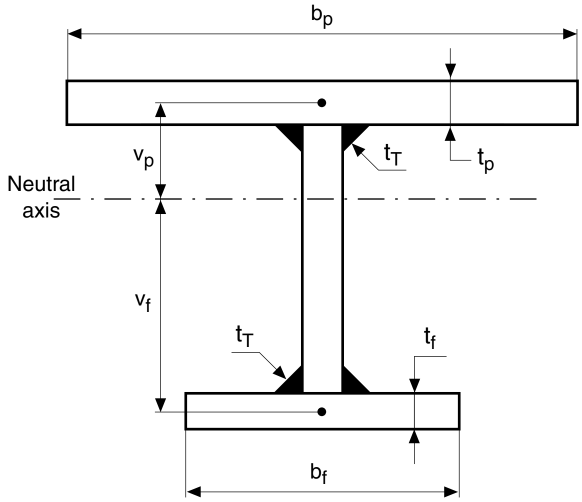
Where deemed necessary, the minimum throat thickness t_T of a double continuous fillet weld between stiffener web and associated plating and/or flange, in mm, may be determined as follows:

$$t_T \geq \frac{T \cdot m}{2 \cdot I \cdot \tau} \geq t_{Tmin}$$

where:

- T : Shear force, in N, in the considered section of the stiffener
- I : Inertia, in mm^4, of the stiffener
- τ : Permissible shear stress, in N/mm^2, as defined in Ch 5, Sec 3
- t_{Tmin} : Minimum throat thickness defined in [2.6.3]
- m : Value, in mm^3, calculated as follows (see Fig 1):
  - for weld between flange and web: $m = t_f \cdot b_f \cdot v_f$
  - for weld between associated plate and web: $m = t_p \cdot b_p \cdot v_p$

Figure 1 :



2.6.5 Throat thickness of intermittent weld

The throat thickness t_{IT}, in mm, of intermittent welds is to be not less than:

$$t_{IT} \equiv t_T \frac{p}{d}$$

where:

- t_T : Throat, in mm, of the double continuous fillet weld, equal to: $t_T = w_F\, t$

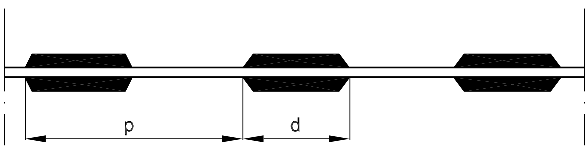
  with:

  w_F, t : As defined in [2.6.3]
- p, d : As defined as follow:
  - chain welding (see Fig 2):

    $d \geq 75$ mm

    $p - d \leq 200$ mm

Figure 2 : Intermittent chain welding



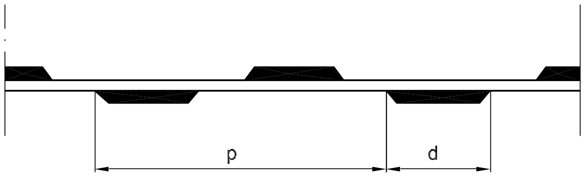
- staggered welding (see Fig 3):

  $d \geq 75$ mm

  $p - 2\, d \leq 300$ mm

  $p \leq 2\, d$ for connections subjected to high alternate stresses.

Figure 3 : Intermittent staggered welding



2.6.6 Fillet weld in way of cut-outs

The throat thickness of the welds between the cut-outs in primary supporting member webs for the passage of ordinary stiffeners is to be not less than the value obtained, in mm, from the following formula:

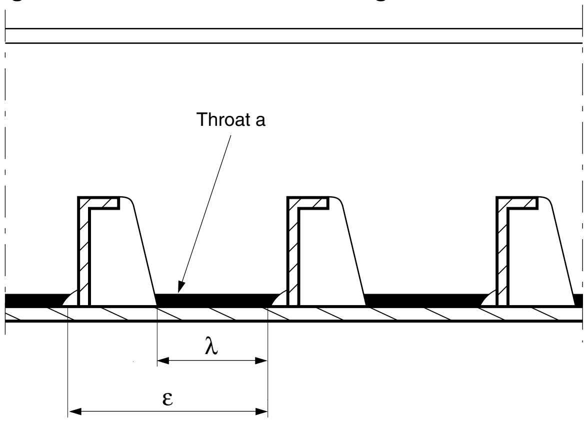
$$t_{TC} = t_T \frac{\varepsilon}{\lambda}$$

where:

t_T : Throat thickness defined in [2.6.3]

ε, λ : Dimensions, in mm, to be taken as shown in Fig 4.

Figure 4 : Continuous fillet welding between cut-outs



2.6.7 Welding between secondary and primary stiffeners

As a general rule, the resistant weld section A_W, in cm², of the fillet weld connecting the ordinary stiffeners to the web of primary members, is not to be less than:

a) General case:

$$A_W = \varphi \cdot p \cdot s \cdot \ell \cdot \left(1 - \frac{s}{2 \cdot \ell}\right) K \cdot 10^{-3}$$

where:

φ : Coefficient as indicated in Tab 3

p : Design pressure, in kN/m², acting on the secondary stiffeners

s : Spacing of ordinary stiffeners, in m

ℓ : Span of ordinary stiffeners, in m

K : Greatest material factor of ordinary stiffener and primary member, as defined in Ch 5, Sec 1.

b) Case of side shell impact:

$$A_W = \varphi s P\left(0{,}6 - \frac{s}{4}\right) k 10^{-3}$$

where:

s : Spacing of secondary stiffeners, in m, without being taken greater than 0,6 m

P : Pressure, in KN/m², to be taken equal to: $P = C_p\ P_{ssmin}$

C_p : Pressure coefficient equal to: $C_p = -0{,}98s^2 + 0{,}3s + 0{,}95 \geq 0{,}8$

p_{ssmin} : Impact pressure, in kN/m², acting on the secondary stiffeners as defined in Ch 4, Sec 3, [3.1.2].

Table 3 : Coefficient φ

Case	Weld	φ
1	Parallel to the reaction exerted on primary member	100
2	Perpendicular to the reaction exerted on primary member	75

3 Typical joint preparation

3.1 General

3.1.1 The type of connection and the edge preparation are to be appropriate to the welding procedure adopted, the structural elements to be connected and the stresses to which they are subjected.

3.2 Butt welding

3.2.1 Permissible root gap between elements to be welded and edge preparations are to be defined during qualification tests of welding procedures and indicated in the welding booklet.

For guidance purposes, typical edge preparations and gaps are indicated in Tab 4.

3.2.2 In case of welding of two plates of different thickness equal to or greater than:

- 3 mm, if the thinner plate has a thickness equal to or less than 10 mm, or
- 4 mm, if the thinner plate has a thickness greater than 10 mm,

a taper having a length of not less than 4 times the difference in thickness is to be adopted for connections of plating perpendicular to the direction of main stresses. For connections of plating parallel to the direction of main stresses, the taper length may be reduced to 3 times the difference in thickness.

When the difference in thickness is less than the above values, it may be accommodated in the weld transition between plates.

For large thicknesses (e.g. 25 mm), other criteria may be considered on a case by case basis, when deemed equivalent.

3.2.3 Butt welding on backing

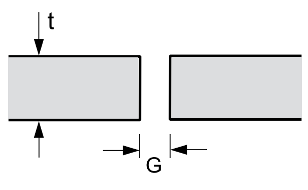
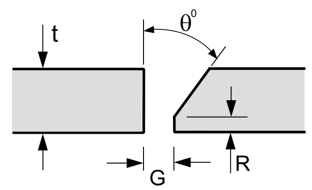
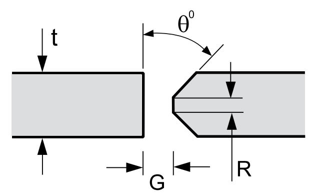
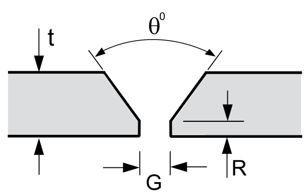
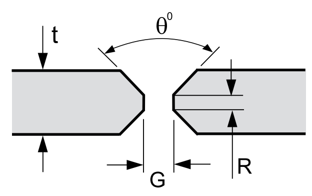
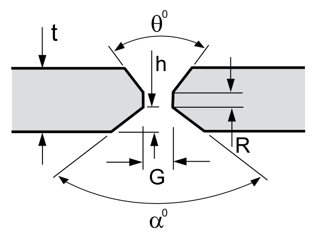
For butt welding on temporary or permanent backing, the edge preparations and gaps are to be defined by the shipyard, taking into account the type of backing plate.

3.2.4 Section, bulbs and flat bars

Stiffeners contributing to the longitudinal or transversal strength, or elements in general subject to high stresses, are to be connected together by butt joints with full penetration weld. Other solutions may be adopted if deemed acceptable by the Society on a case by case basis.

The work is to be done in accordance with an approved procedure, in particular, for work done on board or in conditions of difficult access to the welded connection where special measures may be required by the Society.

Table 4 : Typical butt weld plate edge preparation (manual welding) - See Note 1

Square butt	Single bevel butt	Double bevel butt
 $t \leq 5$ mm G = 3 mm	 $t > 5$ mm $\quad$ $R \leq 3$ mm $G \leq 3$ mm $\quad$ $50° \leq \theta \leq 70°$	 $t > 19$ mm $\quad$ $R \leq 3$ mm $G \leq 3$ mm $\quad$ $50° \leq \theta \leq 70°$
Single vee butt	**Double vee butt, uniform bevels**	**Double vee butt, non-uniform bevels**
 $G \leq 3$ mm $\quad$ $50° \leq \theta \leq 70°$ $R \leq 3$ mm	 $G \leq 3$ mm $\quad$ $50° \leq \theta \leq 70°$ $R \leq 3$ mm	 $G \leq 3$ mm $\quad$ $\theta = 50°$ $R \leq 3$ mm $\quad$ $\alpha = 90°$ $6 \leq h \leq t/3$ mm
Note 1: Different plate edge preparation may be accepted or approved by the Society on the basis of an appropriate welding procedure specification.		

3.3 Fillet weld

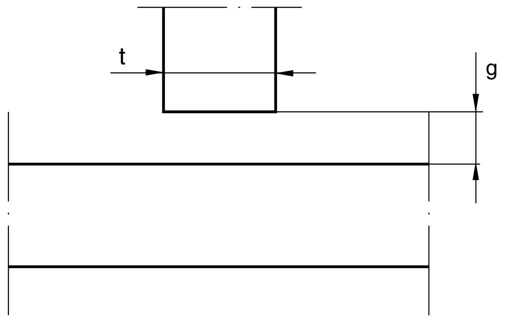
3.3.1 Clearance

In fillet weld T connections, a gap g, as shown in Fig 5, not greater than 2 mm may be accepted without increasing the throat thickness calculated according to [2.6.3] to [2.6.6] as applicable.

In the case of a gap greater than 2 mm, the above throat thickness is to be increased.

In any event, the gap g may not exceed 4 mm.

Figure 5 : Gap in fillet weld T connections



3.3.2 Preparation and penetration of fillet weld

Where partial or full T penetration welding are adopted for connections subjected to high stresses for which fillet welding is considered unacceptable by the Society, typical edge preparations are indicated in:

- for partial penetration welds: Fig 6 a) Fig 7, in which f, in mm, is to be taken between 3 mm and T/3, and α between 45° and 60°
- for full penetration welds: Fig 6 c), in which f, in mm, is to be taken between 0 and 3 mm, and α between 45° and 60°. Back gouging may be required for full penetration welds.

Figure 6 : Partial penetration weld

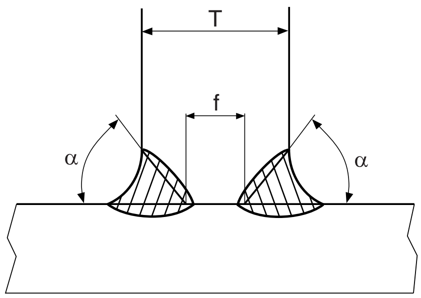


Figure 7 : Partial penetration weld

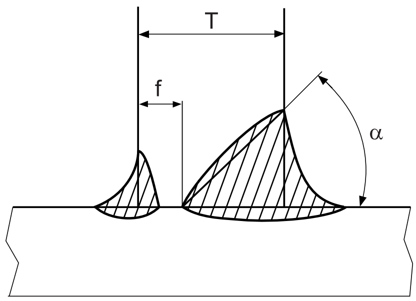
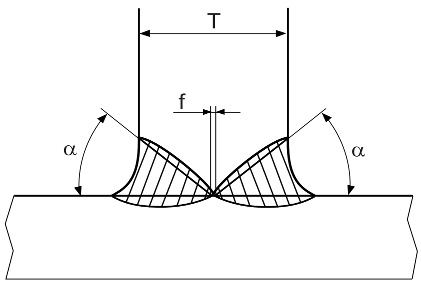


Figure 8 : Full penetration weld



3.3.3 Lamellar tearing

Precautions are to be taken in order to avoid lamellar tears, which may be associated with:

- cold cracking when performing T connections between plates of considerable thickness or high restraint
- large fillet welding and full penetration welding on higher strength steels.

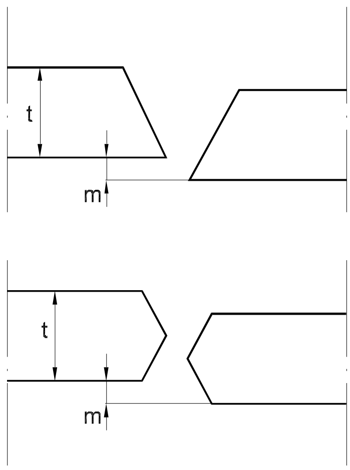
4 Plate misalignment

4.1 Misalignment in butt weld

4.1.1 Plate misalignment in butt connections

The misalignment m, measured as shown in Fig 9, between plates with the same thickness is to be less than 15% of the plate thickness without being greater than 3 mm.

Figure 9 : Plate misalignment in butt connections



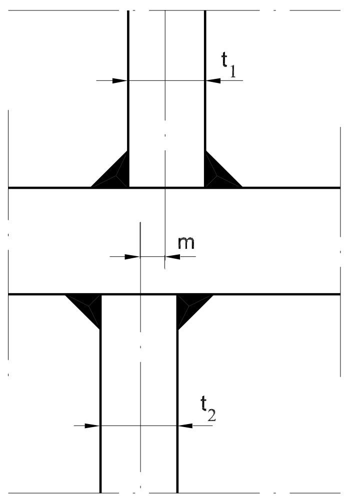
4.2 Misalignment in cruciform connections

4.2.1 Misalignment in cruciform connections

The misalignment m in cruciform connections, measured on the median lines as shown in Fig 10, is to be less than t/2, where t is the thickness of the thinner abutting plate.

The Society may require lower misalignment to be adopted for cruciform connections subjected to high stresses.

Figure 10 : Misalignment in cruciform connections



5 Connection between steel and aluminium

5.1 General

5.1.1 Any direct contact between steel and aluminium alloy is to be avoided.

Heterogeneous jointing system is considered by the Society on a case-by-case basis.

The use of transition joints made of aluminium/steel-clad plates or profiles is to be in accordance with NR216 Materials and Welding.

Section 8 Pillar Scantling

Symbols

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

I : Minimum moments of inertia, in cm⁴, of the pillar in relation to its principal axis

E : Young's modulus, in N/mm², to be taken equal to:

- for steels in general: $E = 2{,}06 \cdot 10^5$ N/mm²
- for stainless steels: $E = 1{,}95 \cdot 10^5$ N/mm²

ℓ : Span, in m, of the pillar

f : Fixity coefficient, to be obtained from Tab 1

R_{eH} : Minimum guaranteed yield stress, in N/mm²

σ_{CB} : Global pillar buckling stress, in N/mm²

σ_{CL} : Local pillar buckling stress, in N/mm².

1 General

1.1 Materials

1.1.1 The buckling check and the scantling criteria are defined in:

- Article [2] for steel pillars
- Article [3] for aluminium pillars

1.2 Application

1.2.1 The requirements of this Section deals with the buckling check of independent profiles pillars or bulkheads stiffeners acting as pillar.

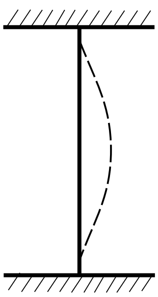
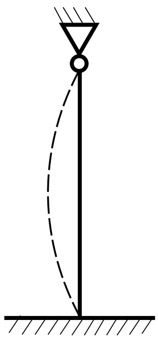
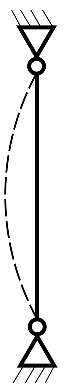
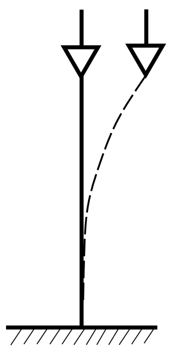
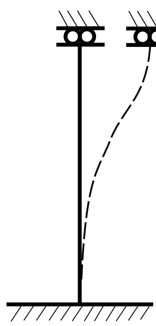
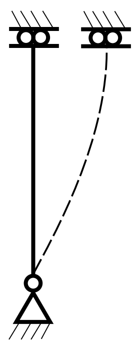
The general requirements relating to pillars arrangement are given in Ch 5, Sec 2, [6.5].

1.2.2 Calculation approach

The pillar buckling stresses σ_{CB} and σ_{CL}, in N/mm², and the maximal allowable axial load P_C, in KN, are to be successively examined according the two following methods:

- global column buckling, and
- local buckling.

Table 1 : Coefficient f

Conditions of fixity						
f	0,5 **(1)**	0,7	1,0	2,0	1,0	2,0
(1) End clamped condition may only be considered when the structure in way of pillar ends can not rotate under the effect of loadings.						

1.3 Loads

1.3.1 Deck loads

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

The load factor depends on the relative position of each pillar with respect to that considered (i.e the number of tiers separating the two pillars).

The compression axial load F_A in the pillar is to be obtained, in kN, from the following formula:

$$F_A = A_D p_s + \sum_i r Q_i$$

where:

A_D : Area, in m², of the portion of the deck or the platform supported by the pillar considered

p_s : Pressure on deck, in kN/m², as defined in Ch 4, Sec 4, [1]

r : Load factor depending on the relative position of each pillar above the one considered, to be taken equal to:

- r = 0,9 for the pillar immediately above the pillar considered
- $r = 0{,}9^i > 0{,}478$ for the i^{th} pillar of the line above the pillar considered

Q_i : Vertical local load, in kN, supported by the i^{th} pillar of the line above the pillar considered, if any.

1.3.2 Mast loads for sailing yacht

For sailing yachts, when the mast is sustained by a pillar, the compression axial load F_M in the pillar is to be obtained, in kN, from the following formula:

$$F_M = a_v P_M + F_C + F_A$$

where:

P_M : Weight, in KN, of the mast

F_C : Maximum compression force, in KN, induced by the transverse and longitudinal standing rigging (taking into account the initial mast compression due to pre-stressing) to be defined by the Designer

F_A : Compression axial load as defined in [1.3.1]

a_v : Vertical acceleration, expressed in g, to be taken not less than:

- for monohull: As defined in Ch 4, Sec 3, [4.2.4]
- for multihull: 1,3

Note 1: When masts are located on the floats of multihull, the value of the vertical aceleration a_v is to be considered on a case by case basis.

The values of P_M and F_C are to be defined by the designer.

2 Pillar in steel material

2.1 Buckling of pillars subjected to compression axial load

2.1.1 Global critical column buckling stress

The global critical column buckling stress of pillars σ_{CB} is to be obtained, in N/mm², from the following formula:

$$\sigma_{CB} = \sigma_E \quad \text{for} \quad \sigma_E \le \frac{R_{eH}}{2}$$

$$\sigma_{CB} = R_{eH}\left(1 - \frac{R_{eH}}{4\sigma_E}\right) \quad \text{for} \quad \sigma_E > \frac{R_{eH}}{2}$$

where:

σ_E : Euler column buckling stress of the pillar, in N/mm², to be obtain by the following formula:

$$\sigma_E = \pi^2 E \frac{I}{A(f\ell)^2} 10^{-4}$$

2.1.2 Local critical buckling stress

The local critical buckling stress of pillars σ_{CL} is to be obtained, in N/mm², from the following formula:

$$\sigma_{CL} = \sigma_{Ei} \quad \text{for} \quad \sigma_{Ei} \le \frac{R_{eH}}{2}$$

$$\sigma_{CL} = R_{eH}\left(1 - \frac{R_{eH}}{4\sigma_{Ei}}\right) \quad \text{for} \quad \sigma_{Ei} > \frac{R_{eH}}{2}$$

where:

σ_{Ei} : Euler local buckling stress, in N/mm², to be taken equal to the values obtained from the following formula:

- For circular tubular pillars:

$$\sigma_{Ei} = 12,5\left(\frac{E}{206000}\right)\left(\frac{t}{D}\right)10^4$$

where:

t : Pillar thickness, in mm

D : Pillar outer diameter, in mm

- For rectangular tubular pillars:

$$\sigma_{Ei} = 78\left(\frac{E}{206000}\right)\left(\frac{t}{b}\right)^2 10^4$$

where:

b : Greatest dimension of the cross-section, in mm

t : Plating thickness in relation to b, in mm

- For built up pillars, the lesser of:

$$\sigma_{Ei} = 78\left(\frac{E}{206000}\right)\left(\frac{t_W}{h_W}\right)^2 10^4$$

$$\sigma_{Ei} = 32\left(\frac{E}{206000}\right)\left(\frac{t_F}{b_F}\right)^2 10^4$$

where:

h_W : Web height of built-up section, in mm

t_W : Web thickness of built-up section, in mm

b_F : Face plate width of built-up section, in mm

t_F : Face plate thickness of built-up section, in mm.

2.1.3 Maximum allowable axial load

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

a) General case:

$$P_C = \frac{\sigma_{CB}}{1,35}A \cdot 10^{-1}$$

$$P_C = \frac{\sigma_{CL}A}{1,2} \cdot 10^{-1}$$

b) Pillar under mast for sailing yacht:

$$P_C = \frac{\sigma_{CB}}{3}A \cdot 10^{-1}$$

$$P_C = \frac{\sigma_{CL}A}{3} \cdot 10^{-1}$$

2.2 Buckling of pillars subjected to compression axial load and bending moments

2.2.1 Checking criteria

In addition to the requirements in [2.1], the scantling of the pillar loaded by the compression axial load and bending moments are to comply with the following formula:

$$10F\left(\frac{1}{A} + \frac{\Phi e}{w_P}\right) + \left(10^3\frac{M_{max}}{Z_P}\right) \le 0,85R_{eH}$$

where:

F : Actual compression load, in kN, acting on the pillar

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

e : Eccentricity, in cm, of the compression load with respect to the center of gravity of the cross-section

$$\Phi = \frac{1}{1 - \frac{10F}{\sigma_E A}}$$

σ_E : Euler column buckling stress, in N/mm², defined in [2.1.1]

Z_P : Minimum section modulus, in cm³, of the cross-section of the pillar

M_{max} : Max (M_1, M_2, M_0)

M_1 : Bending moment, in kN.m, at the upper end of the pillar

M_2 : Bending moment, in kN.m, at the lower end of the pillar

$$M_0 = \frac{0,5(\sqrt{1+t^2})(M_1+M_2)}{\cos(u)}$$

$$u = 0,5\pi\sqrt{\frac{10F}{\sigma_E A}}$$

$$t = \frac{1}{\tan(u)}\left(\frac{M_2-M_1}{M_2+M_1}\right)$$

provided that:

$$-\tan^2 u \le \frac{M_2-M_1}{M_2+M_1} \le \tan^2 u$$

2.3 Pillars in tanks

2.3.1 Where pillars are submitted to tensile stress due to internal pressure in tanks, brackets or equivalent arrangements are to be provided in way of the connection elements between the pillar and the supported structure of the tank.

Doubling plate are not to be used at pillar ends.

Pillars in tanks are not to be of hollow profile type.

2.4 Vertical bulkhead stiffener acting as pillar

2.4.1 When a vertical stiffening member is fitted on the bulkhead in line with the deck primary supporting member transferring the loads from the deck to the bulkhead (as a pillar), this vertical stiffener is to be calculated as a built up pillar as defined in [2.1] or [2.2], taking into account an associated plating of a width equal to 35 times the plating thickness.

3 Pillar in aluminium material

3.1 General

3.1.1 The global critical column buckling stress σ_{CB} and the local critical buckling stress σ_{CL}, in N/mm², of a pillar built in aluminium material are to be as defined in NR561 Aluminium Ships, Section 8.

3.1.2 Maximum allowable axial load

The maximum allowable axial load P_C, in kN, is to be as defined in NR561 Aluminium Ships, Section 8, taking into account the following values of SF_{CB} and SF_{CL}:

a) General case:

$$SF_{CB} = 0,34\frac{f\ell}{r} + 1,15$$

$SF_{CL} = 1,2$

where:

r : Minimum radius of gyration, in cm, equal to:

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

b) Pillar under mast for sailing yacht:

$SF_{CB} = SF_{CL} = 3$

Section 9 Buckling Analysis of Plating

Symbols

E : Young's modulus, in N/mm², to be taken equal to:

- for steels in general: $E = 2{,}06.10^5$ N/mm²
- for stainless steels: $E = 1{,}95.10^5$ N/mm²

ν : Poisson's ratio of the material

R_{eH_P} : Specified minimum yield stress of the plate, in N/mm²

a : Length of the longer side of the plate panel, in mm

b : Length of the shorter side of the plate panel, in mm

α : Aspect ratio of the plate panel, to be taken as:

$$\alpha = \frac{a}{b}$$

σ_x : Stress applied on the shorter side b of the plate panel as defined in Ch 5, Sec 4

σ_y : Stress applied on the longer side a of the plate panel as defined in Ch 5, Sec 4

τ : Applied shear stress, in N/mm²

σ_E : Elastic buckling reference stress, in N/mm², to be taken as:

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_p}{b}\right)^2$$

t_p : Thickness, in mm, of the plating considered

1 General

1.1 Material

1.1.1 The requirements of this Section apply for the buckling check of steel plates subjected to compression stresses induced by overall bending moment and shear forces due to global hull girder loads.

The buckling check of aluminium alloys plates is to be carried out as defined in NR561 Aluminium Ships, taking into account the buckling check criteria defined in [4].

1.2 Application

1.2.1 Buckling under global hull girder loads

The hull areas to be checked under buckling induced by overall bending moment and shear forces due to global hull girder loads are mainly:

Under compression:

- bottom and/or decks plating
- deck area around mast of monohull sailing yachts (buckling under compression stress on four edges)
- bottom and deck plating of platform of catamarans, in way of platform transverse primary structure
- side shell plating in the upper and lower areas below deck and above bottom
- superstructure contributing to the longitudinal or transverse global strength

Under shear:

- side shell plating
- platform primary transverse structure of catamarans.

Other hull areas may be checked under buckling on a case by case basis when deemed necessary by the Society.

1.2.2 Buckling under local loads

Buckling analysis of plating under local loads is to be carried out:

a) According to Ch 5, Sec 10, [2.4.7] when the plate is examined as an attached plating of stiffener

b) According to the present Sub Article when the plate is submitted to local compression loads taking into account the compression stress applied to the plate induced by local load.

1.3 Calculation hypothesis

1.3.1 The buckling approach defined in the present Section is based on the NI615 Buckling Assessment of Plated Structures, taking into account the following simplifying hypothesis:

- the applied compression stress is considered as uniform along the edges of the plate (the edge ratio Ψ according to NI615 is taken equal to 1)

Note 1:

When the applied compression stress along the edges of the plate is not uniform (ratio Ψ different from 1), the applied stress to consider in the present Section is to be taken equal to the maximum applied compression stress along the edge

- when the buckling check is carried out with bi-axial compression hypothesis, the stresses σ_x and σ_y are as a general rule determined by finite element calculation or direct calculation.

Note 2:

When the compression stress applied on the edge not directly loaded by the global loads is not determined by FEM or direct calculation, this compression stress may be considered as null.

- plate panels are considered as being simply supported on their edges

1.3.2 The buckling approach defined in NI615 Buckling Assessment of Plated Structures may be taken into account instead of the present simplify method when deemed necessary.

2 Sign convention for normal stresses

2.1 General

2.1.1 In the present Section, compression and shear stresses are to be taken as positive.

Tensile stresses are to be taken as negative.

3 Critical stress under buckling

3.1 Critical buckling stresses

3.1.1 Critical buckling stress by compression of the shorter edge of the panel

The ultimate buckling stress of plate panels, in N/mm², induced by compression of the shorter edge of panel, according to Fig 1, is to be taken as:

$$\sigma_{cx}' = C_x R_{eH\_P}$$

where:

C_x : Coefficient equal to

$$C_x = 1{,}00 \text{ for } \lambda \le 0{,}84$$

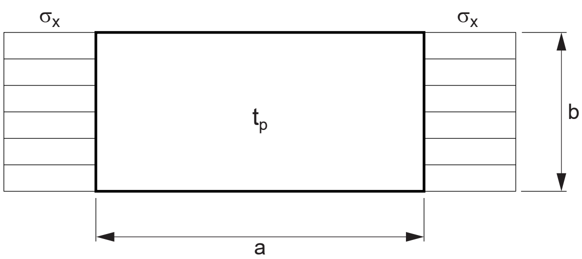
$$C_x = 1{,}13\left(\frac{1}{\lambda} - \frac{0{,}22}{\lambda^2}\right) \text{ for } \lambda > 0{,}84$$

λ : Reference degree of slenderness, to be taken as:

$$\lambda = \sqrt{\frac{R_{eH\_P}}{K_x \sigma_E}}$$

K_x : Buckling factor equal to 4

Figure 1 : Compression of the shorter edge of the panel



3.1.2 Critical buckling stress by compression of the longer edge of the panel

The ultimate buckling stress of plate panel, in N/mm², induced by compression of the longer edge of panel, according to Fig 2 is to be taken as:

$\sigma_{cy}' = C_y R_{eH\_P}$

where:

$$C_y = 1,13\left[\frac{1}{\lambda} - \frac{R + F^2\ (H - R)}{\lambda^2}\right]$$

λ : Reference degree of slenderness, to be taken as:

$$\lambda = \sqrt{\frac{R_{eH\_P}}{K_y \sigma_E}}$$

$$K_y = \left(1 + \frac{1}{\alpha^2}\right)^2$$

R : Coefficient equal to:

$R = 0,22$ for $\lambda \geq 0,84$

$$R = \lambda\left(1 - \frac{\lambda}{1,13}\right) \text{ for } \lambda < 0,84$$

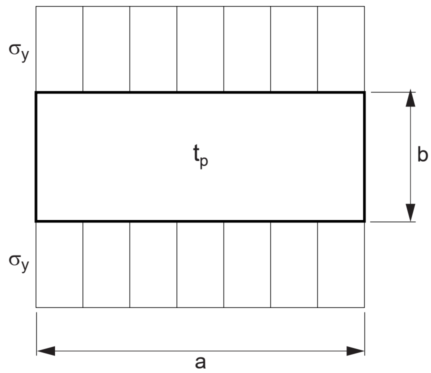
$$F = 1 - \frac{\left(\frac{K_y}{0,91} - 1\right)}{\lambda_p^2} \geq 0$$

$$\lambda_p^2 = \lambda^2 - 0,5 \text{ with } 1 \leq \lambda_p^2 \leq 3$$

$$H = \lambda - \frac{2\lambda}{1,13\ (T + \sqrt{T^2 - 4})} \geq R$$

$$T = \lambda + \frac{14}{15\lambda} + \frac{1}{3}$$

Figure 2 : Compression of the longer edge of the panel



3.1.3 Critical shear buckling stress

The ultimate shear buckling stress of plate panels, in N/mm², according to Fig 3 is to be taken as:

$$\tau_c' = C_\tau \frac{R_{eH\_P}}{\sqrt{3}}$$

where:

C_t : Coefficient equals to:

$$C_\tau = 1,00 \text{ for } \lambda \leq 0,84$$

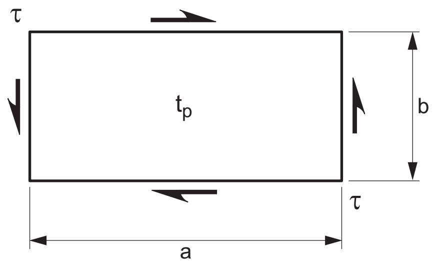
$$C_\tau = \frac{0,84}{\lambda} \text{ for } \lambda > 0,84$$

λ : Reference degree of slenderness, to be taken as:

$$\lambda = \sqrt{\frac{R_{eH\_P}}{K_t \sigma_E}}$$

$$K_\tau = \sqrt{3}\left(5,34 + \frac{4}{\alpha^2}\right)$$

Figure 3 : Shear stress



4 Buckling check criteria

4.1 General

4.1.1 The buckling strength or capacity defined in the present Article takes into account the internal redistribution of loads depending on the load situation, slenderness and type of structure.

4.2 Scantling criteria

4.2.1 The plate scantling is to fulfill the following conditions:

- $$\left(\left(\frac{\sigma_x\ SF}{\sigma'_{cx}}\right)^{e_0}+\left(\frac{\sigma_y\ SF}{\sigma'_{cy}}\right)^{e_0}+\left(\frac{|\tau|\ SF}{\tau'_c}\right)^{e_0}-\Omega\right)\leq 1$$

  with:

  $$\Omega = B\left(\frac{\sigma_x\ SF}{\sigma'_{cx}}\right)^{e_0/2}\left(\frac{\sigma_y\ SF}{\sigma'_{cy}}\right)^{e_0/2}$$

- when $\sigma_x \geq 0$ (compressive)

  $$\left(\left(\frac{\sigma_x\ SF}{\sigma'_{cx}}\right)^{2/\beta_p^{0,25}}+\left(\frac{|\tau|\ SF}{\tau'_c}\right)^{2/\beta_p^{0,25}}\right)\leq 1$$

- when $\sigma_y \geq 0$ (compressive)

  $$\left(\left(\frac{\sigma_y\ SF}{\sigma'_{cy}}\right)^{2/\beta_p^{0,25}}+\left(\frac{|\tau|\ SF}{\tau'_c}\right)^{2/\beta_p^{0,25}}\right)\leq 1$$

- $$\left(\frac{|\tau|\ SF}{\tau'_c}\right)\leq 1$$

where:

σ_x, σ_y : Actual normal stresses applied on the plate panel, in N/mm², respectively in the shorter edge and the longer edge of the panel, taking into account the sign convention for normal stresses defined in [2]

τ : Actual shear stress applied on the plate panel, in N/mm², taking into account the sign convention for normal stresses defined in [2]

σ_{cx}' : Ultimate buckling stress, in N/mm², in the shorter edge of the panel, as defined in [3.1.1]

σ_{cy}' : Ultimate buckling stress, in N/mm², in the longer edge of the buckling panel, as defined in [3.1.2]

τ_c' : Ultimate buckling shear stresses, in N/mm², as defined in [3.1.3]

SF : Safety buckling factor SF_{buck} defined in Ch 5, Sec 3, Tab 1

B, e_0 : As defined in Tab 1

Table 1 : Coefficients B and e_0

Applied stresses	B	e_0
$\sigma_x \geq 0$ and $\sigma_y \geq 0$	$0,7 - 0,3\ \beta_p / \alpha^2$	$2/\beta_p^{0,25}$
$\sigma_x < 0$ or $\sigma_y < 0$	1,0	2,0
Note 1: β_p : Plate slenderness parameter taken as: $\beta_p = \frac{b}{t_p}\sqrt{\frac{R_{eH\_P}}{E}}$		

4.3 Plate capacity

4.3.1 For information, the plate limit state is based on the following interaction formula:

- $$\left(\left(\frac{\gamma_{c1}\ \sigma_x\ SF}{\sigma'_{cx}}\right)^{e_0}+\left(\frac{\gamma_{c1}\ \sigma_y\ SF}{\sigma'_{cy}}\right)^{e_0}+\left(\frac{\gamma_{c1}\ |\tau|\ SF}{\tau'_c}\right)^{e_0}-\Omega\right) = 1$$

- when $\sigma_x \geq 0$ (compressive)

$$\left(\left(\frac{\gamma_{c2}\ \sigma_x\ SF}{\sigma'_{cx}}\right)^{2/\beta_p^{0,25}}+\left(\frac{\gamma_{c2}\ |\tau|\ SF}{\tau'_c}\right)^{2/\beta_p^{0,25}}\right) = 1$$

- when $\sigma_y \geq 0$ (compressive)

$$\left(\left(\frac{\gamma_{c3}\ \sigma_y\ SF}{\sigma'_{cy}}\right)^{2/\beta_p^{0,25}}+\left(\frac{\gamma_{c3}\ |\tau|\ SF}{\tau'_c}\right)^{2/\beta_p^{0,25}}\right) = 1$$

$$\left(\frac{\gamma_{c4}\ |\tau|\ SF}{\tau'_c}\right) = 1$$

where:

γ_c : Applied stress multiplier factor involving the plate buckling failure of the above different limit state

SF : Safety buckling factor SF_{buck} to be taken equal to 1 in the present requirement

The stress multiplier factor as failure, γ_c, is taken as:

$\gamma_c = \text{Min}\ (\gamma_{c1};\ \gamma_{c2};\ \gamma_{c3};\ \gamma_{c4})$

Section 10 Buckling Analysis of Stiffener

Symbols

E : Young's modulus, in N/mm², to be taken equal to:
- for steels in general: E = 2,06.10⁵ N/mm²
- for stainless steels: E = 1,95.10⁵ N/mm²

R_{eH} : Minimum guaranteed yield stress, in N/mm², of the stiffener material, defined in Ch 5, Sec 1

R_{eH_p} : Minimum guaranteed yield stress, in N/mm², of the attached plating, defined in Ch 5, Sec 1

ν : Poisson's ratio of the material

s : Spacing, in m, between stiffeners

h_w, t_w, $b_{f\text{-}out}$:Dimensions of the stiffener, in mm, as defined in Fig 1.

b_f : Total breath, in mm, of the flange.

t_p, t_w, t_f : Thickness, in mm, of the attached plating, web and flange

1 General

1.1 Application

1.1.1 General

The requirements defined in the present section are applicable to secondary and primary stiffeners made of steel for the buckling check induced by:.

- overall bending moment and shear force due to global hull girder loads, and
- bending moment and shear force induced by local loads.

Aluminium alloys stiffeners are to be in accordance with NR561 Hull in Aluminium Alloys.

1.1.2 The hull areas to be checked under buckling induced by overall bending moment and shear forces due to global hull girder loads are defined in Ch 5, Sec 9, [1.2.1].

1.1.3 Pillars and vertical bulkhead stiffeners acting as pillar are to be examined according to Ch 5, Sec 8.

1.1.4 Bulb section

As a rule, the equivalent dimensions, the inertia, section modulus and shear section of bulb section of steel stiffener may be determined according to Ch 5, Sec 5, [3.1.4].

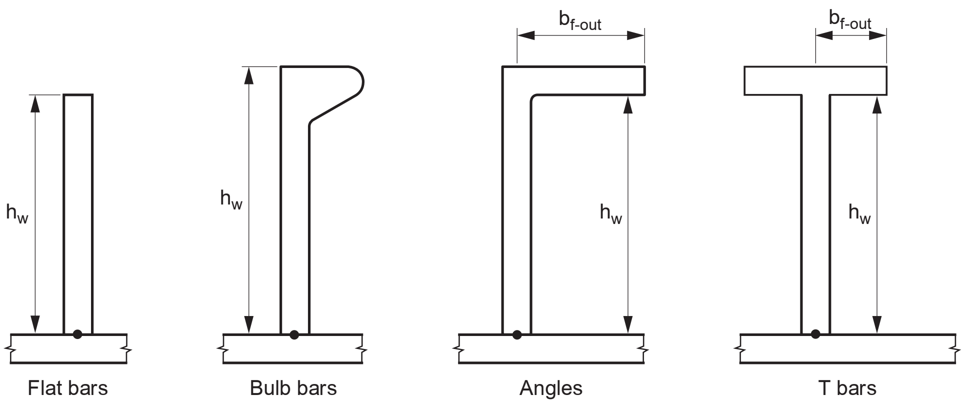
2 Buckling check

2.1 General

2.1.1 The present Article defines the strength criteria for stiffener buckling induced by:

- global axial stresses (see [2.3]) deduced from the global strength analysis
- local bending and shear stresses (see [2.4]) deduced from local loads

Figure 1 : Stiffener scantling parameters



2.2 Sign convention for stresses

2.2.1 General

In the present Article, compressive and shear stresses are to be taken as positive, tension stresses are to be taken as negative.

2.3 Buckling check induced by global axial load

2.3.1 General

The critical buckling stress for secondary or primary supporting member is to be obtained, in N/mm², from the following formula:

$$\sigma_c = \sigma_E \qquad \text{for } \sigma_E \le \frac{R_{eH}}{2}$$

$$\sigma_c = R_{eH}\left(1 - \frac{R_{eH}}{4\sigma_E}\right) \qquad \text{for } \sigma_E > \frac{R_{eH}}{2}$$

where:

$\sigma_E = \min(\sigma_{E1}, \sigma_{E2}, \sigma_{E3})$

σ_{E1} : Euler column buckling stress, in N/mm², given in [2.3.2]

σ_{E2} : Euler torsional buckling stress, in N/mm², given in [2.3.3]

σ_{E3} : Euler web buckling stress, in N/mm², given in [2.3.4].

2.3.2 Column buckling stress

The Euler column buckling stress is obtained, in N/mm², from the following formula:

$$\sigma_{E1} = \pi^2 E \frac{I}{A\ell^2} 10^{-4}$$

I : Moment of inertia, in cm⁴, of the stiffener with attached shell plating about its neutral axis parallel to the plating

A : Sectional area, in cm², of the stiffener with attached plating

ℓ : Span, in m, of the stiffener.

2.3.3 Torsional buckling stress

The Euler torsional buckling stresses is obtained, in N/mm², from the following formula:

$$\sigma_{E2} = \frac{\pi^2 E I_w}{10^4 I_p \ell^2}\left(\frac{K_C}{m^2} + m^2\right) + 0{,}385 E \frac{I_t}{I_p}$$

where:

ℓ : Span, in m, of the stiffener

I_w : Sectoral moment of inertia, in cm⁶, of the stiffener about its connection to the attached plating:

- for flat bars:

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

- for T-sections:

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

- for angles and bulb sections:

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

I_p : Polar moment of inertia, in cm⁴, of the stiffener about its connection to the attached plating:

- for flat bars:

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

- for stiffeners with face plate:

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

I_t : St. Venant's moment of inertia, in cm⁴, of the stiffener without attached plating:

- for flat bars:

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

- for stiffeners with face plate:

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

m : Number of half waves, to be taken equal to the integer number such that (see also Tab 1):

$$m^2(m-1)^2 \leq K_C < m^2(m+1)^2$$

$$K_C = \frac{C_0 \ell^4}{\pi^4 E I_w} 10^6$$

$$C_0 = \frac{E t_p^3}{2{,}73 s} 10^{-3}$$

Table 1 : Number m of half waves

K_C	$0 \leq K_C < 4$	$4 \leq K_C < 36$	$36 \leq K_C < 144$
m	1	2	3

2.3.4 Web buckling stress

The Euler buckling stress of the stiffener web is obtained, in N/mm², from the following formula:

- for flat bars:

$$\sigma_{E3} = 16\left(\frac{t_W}{h_W}\right)^2 10^4$$

- for stiffeners with face plate:

$$\sigma_{E3} = 78\left(\frac{t_W}{h_W}\right)^2 10^4$$

In these formula, h_w is to be taken equal to the height of the web or the spacing of web stiffeners parallel to the flange when the web is stiffened, in m.

2.3.5 Buckling check criteria

The critical buckling stress of the secondary or primary supporting member is to comply with the following formula:

$\sigma_c \geq \sigma \cdot SF$

where:

σ_c : Critical buckling stress, in N/mm², as calculated in [2.3.1]

σ : Actual compression stress in the stiffener, in N/mm², induced by the overall longitudinal bending and/or by the global strength of the catamaran as defined in Ch 5, Sec 4

SF : Safety factor SF_{buck} as defined in Ch 5, Sec 3, Tab 1.

2.4 Buckling check induced by local bending and shear loads

2.4.1 General

As a rule, the present Sub Article is to be applied for primary structure elements.

This Sub Article may be also considered for secondary stiffeners when deemed necessary by the Society.

2.4.2 Calculation hypothesis

The buckling approach defined in the present section is based on the NI615 Buckling Assessment of Plated Structures, taking into account the following simplifying hypothesis:

a) Web:
   - the web panels are considered as being simply supported on their edge, except for flat bar where the top of the web is considered free
   - the bending stress in the web in way of the attached plating is considered equal to 0

b) Flange:

   the flange panel is considered as being simply supported on three edges

The buckling approach defined in NI615 Buckling Assessment of Plated Structures may be taken into account instead of the present simplify method when deemed necessary.

2.4.3 Buckling check area of the stiffeners

The buckling areas and the values of local bending moments and shear forces to consider when a buckling check is carried out are defined in Tab 2 for the different stiffener elements.

Table 2 : Buckling check areas

Stiffener element	Type of load	End stiffener conditions	Buckling under bending		Buckling under shear for web	
			Area to be checked	Value of bending moment M', in kNm	Area to be checked	Value of shear force T', in kN
Attached plating (according to [2.4.7])	Sea pressure or deck loads	Fixed	Mid span	M/2	Not applicable	
		Simply supported or intermediate conditions	Mid span	M		
	Internal pressure	Fixed	End	M		
		Simply supported or intermediate conditions	Not applicable			
Web and flange (according to [2.4.5] or [2.4.6])	Sea pressure or deck loads	Fixed	End	M	End	T
		simply supported or intermediate conditions	Not applicable		End	T
	Internal pressure	Fixed	Mid span	M/2	End	T **(1)**
		simply supported or intermediate conditions	Mid span	M	End	T **(1)**

(1) Bending stress and shear stress buckling are to be examined independently
Note 1: M and T are the bending moments, in kNm, and shear forces, in kN, induced by local loads according to Ch 5, Sec 5 to be taken equal to:
$M = Z.\sigma_{loacam}.10^{-3}$
$T = A_{sh}.\tau_{locam}.10^{-1}$
where:
Z, A_{sh}, σ_{locam}, τ_{locam}:As defined in Ch 5, Sec 5

2.4.4 Buckling reference stress

The elastic buckling reference stress, in N/mm², to be taken as:

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t}{b}\right)^2$$

where:

t : Thickness, in mm, of the considered element of the stiffener (t_w, t_{fl} or t_p)

b : Height of web h_w (or spacing of web stiffeners parallel to the flange when web is stiffened), or breadth of flange $b_{f\text{-}out}$, or shorter edge of the attached plating, in mm.

2.4.5 Flat bar

a) The ultimate buckling stress of the web of flat bar, in N/mm², induced by local bending stress is to be taken as:

$\sigma_{cx}' = C_x R_{eH}$

where:

C_x : Coefficient equal to:

$$C_x = 1,00 \quad \text{for } \lambda \le 0,7$$

$$C_x = \frac{1}{\lambda^2 + 0,51} \quad \text{for } \lambda > 0,7$$

$$\lambda = \sqrt{\frac{R_{eH}}{K_x \sigma_E}}$$

$$K_x = \left(0,425 + \frac{1}{\alpha^2}\right)\frac{3}{2}$$

$\alpha = \ell_w / h_w$

ℓ_w : length of the web, in mm, between vertical web stiffener.

b) The ultimate buckling stress of the web of flat bar induced by local shear stress, in N/mm², is to be taken as:

$$\tau_c' = C_\tau \frac{R_{eH}}{\sqrt{3}}$$

where:

C_t : Coefficient equal to:

$$C_\tau = 1,00 \text{ for } \lambda \le 0,84$$

$$C_\tau = \frac{0,84}{\lambda} \text{ for } \lambda > 0,84$$

$$\lambda = \sqrt{\frac{R_{eH}}{K_t \sigma_E}}$$

$$K_\tau = \sqrt{3}\left(0,6 + \frac{4}{\alpha^2}\right)$$

$\alpha = \ell_w / h_w$

ℓ_w : length of the web, in mm, between vertical web stiffener

h_w : in this formula, h_w is to be taken equal to the height of the web or the spacing of web stiffeners parallel to the flange when the web is stiffened, in m.

c) Buckling check criteria:

The web scantling is to fulfill the following condition:

$$\left(\left(\frac{\sigma_x\, SF}{\sigma_{cx}'}\right)^{e_0} + \left(\frac{|\tau|\, SF}{\tau_c'}\right)^{e_0}\right) \le 1$$

where:

σ_x : Actual bending stress applied to the top of the web, in N/mm^2,equal to:

$$\sigma_x = (M' 10^3)/Z_{acttop}$$

τ : Actual web shear stress, in N/mm^2, to be taken equal to:

$$\tau = (T' 10)/A_{act}$$

M′, T′ : As defined in Tab 2

Z_{acttop} : Actual flat bar modulus, in cm^3, calculated at the top of the flat bar

A_{act} : Actual flat bar shear section, in cm^2, of the flat bar

σ_{cx}' : Ultimate buckling stress, in N/mm^2, defined in a)

τ_c' : Ultimate buckling shear stresses, in N/mm^2, defined in b)

SF : Safety buckling factor SF_{buck} defined in Ch 5, Sec 3, Tab 2

$$e_0 = 2/\beta_p^{0,25}$$

$$\beta_p = \frac{h_w}{t_w}\sqrt{\frac{R_{eH}}{E}}$$

2.4.6 T-bar and angle bar

a) The ultimate buckling stress of the web of T-bar and angle bar, in N/mm^2, induced by local bending stress is to be taken as:

$\sigma_{cx}' = C_x R_{eH}$

where:

C_x : Coefficient equals to:

$C_x = 1{,}0$ for $\lambda \le \lambda_c$

$$C_x = 1,25\left(\frac{1}{\lambda} - \frac{0,22}{\lambda^2}\right) \text{ for } \lambda > \lambda_c$$

$$\lambda = \sqrt{\frac{R_{eH}}{K_x \sigma_E}}$$

$K_x = 7{,}63$

$\lambda_c = 0,965$

b) The ultimate buckling stress of the web of T-bar and angle induced by local shear stress, in N/mm^2, is to be taken as:

$$\tau_c' = C_\tau \frac{R_{eH}}{\sqrt{3}}$$

where:

C_t : Coefficient equals to:

$$C_\tau = 1,00 \text{ for } \lambda \le 0,84$$

$$C_\tau = \frac{0,84}{\lambda} \text{ for } \lambda > 0,84$$

$$\lambda = \sqrt{\frac{R_{eH}}{K_t \sigma_E}}$$

$$K_\tau = \sqrt{3}\left(5,34 + \frac{4}{\alpha^2}\right)$$

$\alpha = \ell_w/h_w$

ℓ_w : length of the web, in mm, between vertical web stiffener

In these formula, h_w is to be taken equal to the height of the web or the spacing of web stiffeners parallel to the flange when the web is stiffened, in m.

c) The ultimate buckling stress of the flange of T-bar and angle bar, in N/mm², induced by local bending stress is to be taken as:

$\sigma_{cx}' = C_x R_{eH}$

where:

C_x : Coefficient equals to:

$$C_x = 1,00 \text{ for } \lambda \le 0,7$$

$$C_x = \frac{1}{\lambda^2 + 0,51} \text{ for } \lambda > 0,7$$

$$\lambda = \sqrt{\frac{R_{eH}}{K_x \sigma_E}}$$

$$K_x = \left(0,425 + \frac{1}{\alpha^2}\right)$$

$\alpha = \ell_w/b_{f\text{-out}}$

ℓ_w : length of the flange, in mm, between flange tripping bracket

d) Buckling check criteria:

- The web scantling is to fulfill the following condition:

$$\left(\left(\frac{\sigma_x\, SF}{\sigma'_{cx}}\right)^{e_0} + \left(\frac{|\tau|\, SF}{\tau'_c}\right)^{e_0}\right) \le 1$$

where:

σ_x : Actual bending stress applied to the top of the web, in N/mm²,equal to:

$$\sigma_x = (0,9M'10^3)/Z_{actfl}$$

τ : Actual web shear stress, in N/mm², to be taken equal to:

$$\tau = (T'10)/A_{act}$$

M’, T’ : As defined in Tab 2

Z_{actfl} : Actual stiffener modulus, in cm³, calculated at the top of the flange

A_{act} : Actual web shear section, in cm², of the stiffener

σ_{cx}' : Ultimate buckling stress, in N/mm², defined in a)

τ_c' : Ultimate buckling shear stress, in N/mm² defined in b)

SF : Safety buckling factor SF_{buck} defined in Ch 5, Sec 3, Tab 2

$$e_0 = 2/\beta_p^{0,25}$$

$$\beta_p = \frac{h_w}{t_w}\sqrt{\frac{R_{eH}}{E}}$$

- The flange scantling is to fulfill the following condition:

$$\left(\frac{\sigma_1\, SF}{\sigma'_{cx}}\right)^{e_0} \le 1$$

where:

σ_1 : Actual bending stress applied to the flange, in N/mm²,equal to:

$$\sigma_1 = (M'10^3)/Z_{actfl}$$

Z_{actfl} : Actual stiffener modulus, in cm³, calculated at the top of the flange

σ_{cx}' : Ultimate buckling stress, in N/mm² defined in c)

SF : Safety buckling factor SF_{buck} defined in Ch 5, Sec 3, Tab 2

$$e_0 = 2/\beta_p^{0,25}$$

$$\beta_p = \frac{b_{f-out}}{t_f}\sqrt{\frac{R_{eH}}{E}}$$

2.4.7 Attached plating

a) General:

The buckling check of the attached plating of stiffener is to be checked in the area where the attached plating is submitted to compressive stresses.

The dimensions of the attached plating to be considered are:

- loaded edge: spacing between stiffeners parallel to the considered stiffener
- unloaded edge: spacing between stiffeners perpendicular to the considered stiffener

b) Case where the loaded edge is the shorter edge of the plate:

The ultimate buckling stress of the attached plating, in N/mm², induced by local bending stress is to be taken as:

$\sigma_{cx}' = C_x R_{eH\_P}$

where:

C_x : Coefficient equals to:

$C_x = 1,0$ for $\lambda \le 0,84$

$$C_x = 1,13\left(\frac{1}{\lambda} - \frac{0,22}{\lambda^2}\right) \quad \text{for } \lambda > 0,84$$

$$\lambda = \sqrt{\frac{R_{eH\_P}}{K_x \sigma_E}}$$

$K_x = 4$

c) Case where the loaded edge is the longer edge of the plate:

The ultimate buckling stress of the attached plating, in N/mm², induced by local bending stress is to be taken as:

$\sigma_{cy}' = C_y R_{eH\_P}$

where:

$$C_y = 1,13\left[\frac{1}{\lambda} - \frac{R + F^2 (H - R)}{\lambda^2}\right]$$

$$\lambda = \sqrt{\frac{R_{eH\_P}}{K_y \sigma_E}}$$

$$K_y = \left(1 + \frac{1}{\alpha^2}\right)^2$$

α : ratio between the longer edge and the shorter edge of the attached plating

R : $R = 0,22$ for $\lambda \ge 0,84$

$$R = \lambda\left(1 - \frac{\lambda}{1,13}\right) \quad \text{for } \lambda < 0,84$$

$$F = 1 - \frac{\left(\frac{K_y}{0,91} - 1\right)}{\lambda_p^2} \ge 0$$

$$\lambda_p^2 = \lambda^2 - 0,5 \quad \text{with } 1 \le \lambda_p^2 \le 3$$

$$H = \lambda - \frac{2\lambda}{1,13\ (T + \sqrt{T^2 - 4})} \ge R$$

$$T = \lambda + \frac{14}{15\lambda} + \frac{1}{3}$$

d) Buckling check criteria:

The attached plating scantling is to fulfill the following condition:

$$\left(\frac{\sigma_i\ SF}{\sigma_c'}\right)^{e_0} \le 1$$

where:

σ_i : Actual bending stress applied in the attached plating in the shorter or longer edge, in N/mm², equal to:

$$\sigma_i = (M' 10^3)/Z_{actap}$$

Z_{actap} : Actual stiffener modulus, in cm³, calculated at the associated plating

σ_c' : Ultimate buckling stress in the shorter edge σ_{cx}' or in the longer edge, σ_{cy}' in N/mm² defined in a) or b)

SF : Safety buckling factor SF_{buck} defined in Ch 5, Sec 3, Tab 2

$$e_0 = 2/\beta_p^{0,25}$$

$$\beta_p = \frac{b}{t_p}\sqrt{\frac{R_{eH\_P}}{E}}$$

b : Shorter edge of the attached plating, in mm.

2.5 Web stiffening arrangement for primary supporting members

2.5.1 General arrangement

As a rule, the requirements of the present Sub-article may not be considered on a case by case basis when buckling check of primary supporting members according to [2.3] and [2.4] is carried out.

2.5.2 Webs of primary supporting members are generally to be stiffened where the height, in mm, is greater than 100 t, where t is the web thickness, in mm, of the primary supporting member.

In general, the web stiffeners of primary supporting members are to be spaced not more than 110 t.

2.5.3 The moment of inertia I, in cm⁴,of stiffeners of web of primary supporting members is to be not less than the value obtained from the following formula:

$$I = 11,4\, s t_w (2,5\, \ell^2 - 2 s^2) \frac{R_{eH}}{235}$$

where:

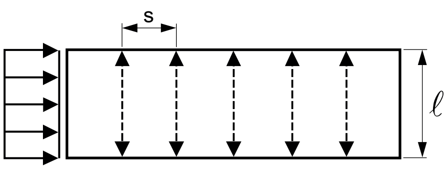
ℓ : Length, in m, of the web stiffener (see Fig 2)

s : Spacing, in m, of web stiffeners (see Fig 2)

t_w : Web thickness, in mm, of the primary supporting member

R_{eH} : Minimum yield stress, in N/mm², of the material of the web of primary supporting member.

Figure 2 : Web stiffeners for primary supporting members



2.5.4 Tripping brackets (see Fig 3) welded to the face plate are generally to be fitted:

- every fourth spacing of ordinary stiffeners
- at the toe of end brackets
- at rounded face plates
- in way of cross ties
- in way of concentrated loads.

Where the width of the symmetrical face plate is greater than 400 mm, backing brackets are to be fitted in way of the tripping brackets.

2.5.5 The arm length d of tripping brackets is to be not less than the greater of the following values, in m:

$$d = 0,38b$$

$$d = 0,85b\sqrt{\frac{s_t}{t}}$$

where:

b : Height, in m, of tripping brackets, shown in Fig 3

s_t : Spacing, in m, of tripping brackets

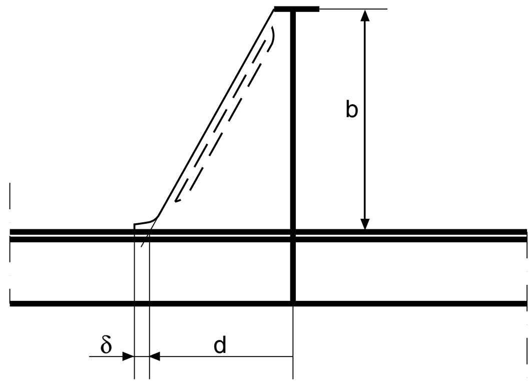
t : Thickness, in mm, of tripping brackets.

It is recommended that the bracket toe should be designed as shown in Fig 3.

2.5.6 Tripping brackets with a thickness, in mm, less than 16,5 times the length in m of the free edge of the bracket are to be flanged or stiffened by a welded face plate.

The sectional area, in cm^2, of the flanged edge or the face plate is to be not less than 10 times the length in m of the free edge of the bracket.

Figure 3 : Primary supporting member: web stiffener in way of ordinary stiffener



Section 11 Hull Construction Survey And Testing

1 General

1.1 Scope

1.1.1 The purpose of this Section is to define hull construction and survey requirements within the scope of the classification of yachts and/or certification of yacht hulls built in steel materials.

Equivalent requirements are defined in NR561 Aluminium Ships, for yachts built in aluminium.

The scope of classification is defined in NR467 Rules for Steel Ships, Part A.

2 Structure drawing examination

2.1 General

2.1.1 The structure drawings submitted within the scope of the classification and or certification are to include the details of the welded connections between the main structural elements, including throat thicknesses and joint types, as far as class is concerned.

A weld booklet, as defined in Ch 5, Sec 7, [1.3] may be requested.

Note 1: For the various structural typical details of welded construction in shipbuilding and not dealt with in this Section, the rules of good practice, recognized standards and past experience are to apply as agreed by the Society.

2.1.2 Where several steel types are used, a plan showing the location of the various steel types is to be submitted at least for outer shell, deck and bulkhead structures.

3 Hull construction and shipyard procedures

3.1 Shipyard details and procedures

3.1.1 The following details are to be submitted by the Shipyard to the Society:

- design office and production work staff
- production capacity (number of units per year, number of types, sizes)
- total number of hull units already built.

3.1.2 The following procedures are to be submitted by the Shipyard to the Society:

- Traceability
  - procedure to ensure traceability of materials, consumable and equipment covered by the Society's Rules (from the purchase order to the installation or placing on ship)
  - data to ensure traceability of the production means (describing the different steps such as inspection or recording during production)
  - handling of non-conformities (from the reception of materials or equipment to the end of construction)
  - handling of client complaints and returns to after-sales department.
- Construction
  - procedure to ensure that the hull is built in accordance with the approved drawings, as defined in [2]
  - procedure to precise the equipment references, the references to any equipment approval, the suppliers' technical requirements, the precautions to be taken when installing the equipment
  - builder's inspection process and handling of defects
  - procedure to ensure that the remedial measures concerning the defects and deficiencies noticed by the Surveyor of the Society during the survey are taken into account.

    Procedures are also to define:

    - the precautions to be taken to comply with the suppliers and Society requirements in order not to cause, during installation, structure damages affecting structural strength and watertightness, and
    - the preparations to be made on the hull in anticipation of installation.

3.2 Materials

3.2.1 The following details about materials used are to be submitted by the Shipyard to the Society:

- list of steel types used for plates, stiffeners, filler products etc., with their references and suppliers' identification
- references of existing material approval certificates
- material data sheets containing, in particular, the suppliers' recommendations on storage use.

3.2.2 The storage conditions of materials and welding consumable are to be in accordance with the manufacturers' recommendations, in dry places without condensation and clear of the ground.

All the materials are to be identifiable in the storage site (type of steel and welding consumable, reference of batches and type of approval certificate,...).

The builder is to provide an inspection to ensure that the incoming plates, stiffeners and consumable are in accordance with the purchase batches and that defective materials have been rejected.

3.3 Forming

3.3.1 Forming operations are to be in accordance with the material manufacturer's recommendation or recognized standard.

3.4 Welding

3.4.1 Welding booklet

A welding booklet, including the welding procedures, filler products and the design of joints (root gap and clearance), as well as the sequence of welding provided to reduce to a minimum restraint during welding operations, is to be submitted to the Surveyor for examination.

Moreover, the welding booklet is:

- to indicate, for each type of joint, the preparations and the various welding parameters
- to define, for each type of assembly, the nature and the extent of the inspections proposed, in particular those of the non-destructive testing such as dye-penetrant tests and, if needed, those of the radiographic inspection.

3.4.2 Welding consumable

The various consumable materials for welding are to be used within the limits of their approval and in accordance with the conditions of use specified in the respective approval documents.

- Welding filler product

  The choice of the welding filler metal is to be made taking into account the welding procedure, the assembly and the grade of steel corresponding to the parent metal

  Welding filler products are generally to be approved by the Society and are of type as defined in NR216 Materials and Welding, Ch 11 or of other types accepted as equivalent by the Society.

- Welding consumable and welding procedures adopted are to be approved by the Society.

  The minimum consumable grades to be adopted are specified in Tab 1 depending on the steel grade.

  Consumable used for manual or semi-automatic welding (covered electrodes, flux-cored and flux-coated wires) of higher strength hull structural steels are to be at least of hydrogen-controlled grade H15 (H). Where the carbon equivalent Ceq is not more than 0,41% and the thickness is below 30 mm, any type of approved higher strength consumable may be used at the discretion of the Society.

  Especially, welding consumable with hydrogen-controlled grade H15 (H) and H10 (HH) shall be used for welding hull steel forgings and castings of respectively ordinary strength level and higher strength level.

Manual electrodes, wires and fluxes are to be stored in suitable locations so as to ensuring their preservation in proper condition. Especially, where consumable with hydrogen-controlled grade are to be used, proper precautions are to be taken to ensure that manufacturer's instructions are followed to obtain (drying) and maintain (storage, maximum time exposed, re-backing,...) hydrogen-controlled grade.

3.4.3 Welding procedures

Welding procedures adopted are to be approved by the Society as defined in NR216 Materials and Welding, Chapter 12.

The approval of the welding procedure is not required in the case of manual metal arc welding with approved covered electrodes, except in the case of one side welding on refractory backing (ceramic).

Table 1 : Consumable grades

<table>
<tr><th rowspan="2">Steel grade</th><th colspan="2">Consumable minimum grade</th></tr>
<tr><th>Butt welding, partial and full T penetration welding</th><th>Fillet welding</th></tr>
<tr><td>A</td><td>1</td><td rowspan="3">1</td></tr>
<tr><td>B - D</td><td>2</td></tr>
<tr><td>E</td><td>3</td></tr>
<tr><td>AH32 - AH36
DH32 - DH36</td><td>2Y</td><td rowspan="2">2Y</td></tr>
<tr><td>EH32 - EH36</td><td>3Y</td></tr>
<tr><td colspan="3">Note 1: Welding consumable approved for welding higher strength steels (Y) may be used in lieu of those approved for welding normal strength steels having the same or a lower grade; welding consumable approved in grade Y having the same or a lower grade.
Note 2: In the case of welded connections between two hull structural steels of different grades, as regards strength or notch toughness, welding consumable appropriate to one or the other steel are to be adopted.</td></tr>
</table>

3.4.4 Welder qualification and equipment

- Qualification of welders:

  Welders for manual welding and for semi-automatic welding processes are to be properly trained and are to be certified by the Society according to the procedures given in NR476 Approval Testing of Welders unless otherwise agreed.

  The qualifications are to be appropriate to the specific applications

  Personnel manning automatic welding machines and equipment are to be competent and sufficiently trained.

  The internal organization of the shipyard is to be such as to provide for assistance and inspection of welding personnel, as necessary, by means of a suitable number of competent supervisors.

  Non-destructive tests are to be carried out by qualified personnel, certified by recognized bodies in compliance with appropriate standards.

- Equipment:

  The welding equipment is to be appropriate to the adopted welding procedures, of adequate output power and such as to provide for stability of the arc in the different welding positions.

  In particular, the welding equipment for special welding procedures is to be provided with adequate and duly calibrated measuring instruments, enabling easy and accurate reading, and adequate devices for easy regulation and regular feed.

3.4.5 Weather protection

Adequate protection from the weather is to be provided to parts being welded; in any event, such parts are to be dry.

In welding procedures using bare, cored or coated wires with gas shielding, the welding is to be carried out in weather protected conditions, so as to ensure that the gas outflow from the nozzle is not disturbed by winds and draughts.

3.4.6 Butt connection edge preparation

The edge preparation is to be of the required geometry and correctly performed. In particular, if edge preparation is carried out by flame, it is to be free from cracks or other detrimental notches.

3.4.7 Surface condition

The surfaces to be welded are to be free from rust, moisture and other substances, such as mill scale, slag caused by oxygen cutting, grease or paint, which may produce defects in the welds.

Effective means of cleaning are to be adopted particularly in connections with special welding procedures; flame or mechanical cleaning may be required.

The presence of a shop primer may be accepted, provided it has been approved by the Society.

Shop primers are to be approved by the Society for a specific type and thickness according to NR216 Materials and Welding, Ch 11, Sec 1.

3.4.8 Assembling and gap

The plates of the shell and strength deck are generally to be arranged with their length in the fore-aft direction. Possible exceptions to the above will be considered by the Society on a case by case basis.

The amount of welding to be performed on board is to be limited to a minimum and restricted to easily accessible connections.

The setting appliances and system to be used for positioning are to ensure adequate tightening adjustment and an appropriate gap of the parts to be welded, while allowing maximum freedom for shrinkage to prevent cracks or other defects due to excessive restraint.

The gap between the edges is to comply with the required tolerances or, when not specified, it is to be in accordance with normal good practice.

Welds located too close to one another are to be avoided. The minimum distance between two adjacent welds is considered on a case by case basis, taking into account the level of stresses acting on the connected elements.

3.4.9 Crossing of structural element

In the case of T crossing of structural elements (one element continuous, the other physically interrupted at the crossing) when it is essential to achieve structural continuity through the continuous element (continuity obtained by means of the welded connections at the crossing), particular care is to be devoted to obtaining the correspondence of the interrupted elements on both sides of the continuous element. Suitable systems for checking such correspondence are to be adopted.

3.4.10 Welding sequences and interpass cleaning

Welding sequences and direction of welding are to be determined so as to minimize deformations and prevent defects in the welded connection.

All main connections are generally to be completed before the ship is afloat.

Departures from the above provision may be accepted by the Society on a case by case basis, taking into account any detailed information on the size and position of welds and the stresses of the zones concerned, both during ship launching and with the ship afloat.

After each run, the slag is to be removed by means of a chipping hammer and a metal brush; the same precaution is to be taken when an interrupted weld is resumed or two welds are to be connected.

3.4.11 Preheating

Suitable preheating, to be maintained during welding, and slow cooling may be required by the Society on a case by case basis.

3.5 Inspection and check

3.5.1 General

Materials, workmanship, structures and welded connections are to be subjected, at the beginning of the work, during construction and after completion, to inspections by the Shipyard suitable to check compliance with the applicable requirements, approved plans and standards.

The manufacturer is to make available to the Surveyor a list of the manual welders and welding operators and their respective qualifications.

The manufacturer's internal organization is responsible for ensuring that welders and operators are not employed under improper conditions or beyond the limits of their respective qualifications and that welding procedures are adopted within the approved limits and under the appropriate operating conditions.

The manufacturer is responsible for ensuring that the operating conditions, welding procedures and work schedule are in accordance with the applicable requirements, approved plans and recognized good welding practice.

3.5.2 Visual and non destructive examinations

After completion of the welding operation and workshop inspection, the structure is to be presented to the Surveyor for visual examination at a suitable stage of fabrication.

As far as possible, the results on non-destructive examinations are to be submitted.

Non-destructive examinations are to be carried out with appropriate methods and techniques suitable for the individual applications, to be agreed with the Surveyor on a case by case basis.

Radiographic examinations are to be carried out on the welded connections of the hull in accordance with [3.5.3]. The results are to be made available to the Society. The surveyor may require to witness some testing preparations.

The Society may allow radiographic examinations to be replaced by ultrasonic examinations.

When the visual or non-destructive examinations reveal the presence of unacceptable indications, the relevant connection is to be repaired to sound metal for an extent and according to a procedure agreed with the Surveyor. The repaired zone is then to be submitted to non-destructive examination, using a method deemed suitable by the Surveyor to verify that the repair is satisfactory.

Additional examinations may be required by the Surveyor on a case by case basis.

Ultrasonic and magnetic particle examinations may also be required by the Surveyor in specific cases to verify the quality of the base material.

3.5.3 Radiographic inspection

A radiographic inspection is to be carried out on the welded butts of shell plating, strength deck plating as well as of members contributing to the longitudinal strength. This inspection may also be required for the joints of members subject to heavy stresses.

The present requirements constitute general rules: the number of radiographs may be increased where requested by the Surveyor, mainly where visual inspection or radiographic soundings have revealed major defects, specially for butts of sheerstrake, stringer plate, bilge strake or keel plate.

Provisions alteration to these rules may be accepted by the Society when justified by the organization of the shipyard or of the inspection department; the inspection is then to be equivalent to that deduced from the present requirements.

As far as automatic welding of the panels butt welds during the pre manufacturing stage is concerned, the shipyard is to carry out random non-destructive testing of the welds (radiographic or ultrasonic inspection) in order to ascertain the regularity and the constancy of the welding inspection.

In the midship area, radiographies are to be taken at the joinings of panels.

Each radiography is situated in a butt joint at a cross-shaped welding.

In a given ship cross-section bounded by the panels, a radiography is to be made of each butt of sheerstrake, stringer, bilge and keel plate; in addition, the following radiographies are to be taken:

- bottom plating: two
- deck plating: two
- side shell plating: two each side.

For ships where B + C ≤ 15 m, only one radiography for each of the above items is required.

This requirement remains applicable where panel butts are shifted or where some strakes are built independently from the panels. It is recommended to take most of these radiographies at the intersections of butt and panel seams.

Still in the midship area, a radiographic inspection is to be taken, at random, of the following main members of the structure:

- butts of continuous longitudinal bulkheads
- butts of longitudinal stiffeners, deck and bottom girders contributing to the overall strength
- assembly joints of insert plates at the corners of the openings.

Outwards the midship area, a programme of radiographic inspection at random is to be set up by the shipyard in agreement with the Surveyor for the major points. It is further recommended:

- to take a number of radiographies of the very thick parts and those comprising restrained joint, such as shaft brackets, solid keel and its connection to bottom structure, chain plates welding, stabilizer recesses, masts
- to take a complete set of radiographies or to increase the number of radiographies for the first joint of a series of identical joints. This recommendation is applicable not only to the assembly joints of prefabricated members completed on the slip, but also to joints completed in the workshop to prepare such prefabricated members.

Where a radiography is rejected and where it is decided to carry out a repair, the shipyard is to determine the length of the defective part, then a set of inspection radiographies of the repaired joint and of adjacent parts is to be taken. Where the repair has been decided by the inspection office of the shipyard, the film showing the initial defect is to be submitted to the Surveyor together with the film taken after repair of the joint.

3.5.4 Acceptance criteria

The quality standard adopted by the shipyard is to be submitted to the Society and applies to all constructions unless otherwise specified on a case by case basis.

3.6 Modifications and repairs during construction

3.6.1 General

Deviations in the joint preparation and other specified requirements, in excess of the permitted tolerances and found during construction, are to be repaired as agreed with the Society on a case by case basis.

3.6.2 Gap and weld deformations

Welding by building up of gaps exceeding the required values and repairs of weld deformations may be accepted by the Society upon special examination.

3.6.3 Defects

Defects and imperfections on the materials and welded connections found during construction are to be evaluated for possible acceptance on the basis of the applicable requirements of the Society.

Where the limits of acceptance are exceeded, the defective material and welds are to be discarded or repaired, as deemed appropriate by the Surveyor on a case by case basis.

When any serious or systematic defect is detected either in the welded connections or in the base material, the manufacturer is required to promptly inform the Surveyor and submit the repair proposal.

The Surveyor may require destructive or non-destructive examinations to be carried out for initial identification of the defects found and, in the event that repairs are undertaken, for verification of their satisfactory completion.

3.6.4 Repairs on structure already welded

In the case of repairs involving the replacement of material already welded on the hull, the procedures to be adopted are to be agreed with the Society on a case by case basis.

3.7 Tank and weathertight structure testing

3.7.1 The pressure testing conditions for tanks, watertight and weathertight structures in order to check the tightness and/or the strength of structural elements are defined in NR600 Ships less than 90 m, Ch 7, Sec3.

As a rule, these tests are to be carried out for ships surveyed by the Society during construction within the scope of classification.

4 Survey for unit production

4.1 General

4.1.1 The survey includes the following steps:

- survey at yard with regards to general requirements of [3]
- structure drawing examination (see [2])
- survey at yard during unit production with regards to approved drawings, yard's response to comments made by the Society during structure review examination and construction requirements.

These can only focus on the construction stage in progress during the survey. It is to the responsibility of the inspection department of the yard to present to the Surveyor any defects noted during the construction of the ship.

5 Alternative survey scheme for production in large series

5.1 General

5.1.1 Where the hull construction is made in large series, an alternative survey scheme may be agreed with the Society for hull to be surveyed as far as Classification is concerned or hull to be certified by the Society on voluntary basis.

5.1.2 The general requirements for the alternative survey scheme, BV Mode I, are given in the Society's Rule Note NR320 as amended.

5.2 Type approval

5.2.1 General

The type approval of a hull made of steel and built in large series comprises:

- examination, in accordance with the present Rule Note of drawings and documents defining the main structural components of the hull
- examination of certain items of equipment and their fittings if requested by the Society Rules for the classification and/or certification of ships
- inspection of the first hull (or a hull representing the large series production).

5.2.2 Examination of drawings

The structure drawing examination is to be carried out as defined in [2].

5.2.3 Examination of certain items of equipment

The equipment requiring a particular drawing examination is defined in the present Rule. As a general rule, this equipment consists mainly in portholes, deck hatches and doors.

This examination may be carried out as defined in the Society’s Rules or through an homologation process, at the satisfaction of the Society.

5.2.4 Inspections

The purpose of the inspections, carried out by a Surveyor of the Society on the initial hull of the series (or a representative hull of the series), is to make surveys at yard during unit production with regards to approved drawings, yard's response to comments made by the Society during structure review examination and construction requirements as listed in [3].

5.2.5 Type Approval Certificate

A Type Approval Certificate (TAC) is issued for the initial hull covered by the type approval procedure.

5.3 Quality system documentation

5.3.1 The quality system documentation submitted to the Society is to include the information required in [3.1] and in the Rule Note NR320 as amended.

5.4 Manufacturing, testing and inspection plan (MTI plan)

5.4.1 For each type of hull, the manufacturing, testing and inspection plan is to detail specifically:

- Materials:

  Special requirements of the supplier (storage conditions, type of checks to be performed on incoming products and properties to be tested by the yard before use).

  - Storage conditions:

    Information about storage sites (ventilation conditions to avoid condensation, supplier data sheets specifying the storage conditions, listing documents to record arrival and departure dates for consignment).

- Reception:

  Information about consignment (traceability of consignment specifying date of arrival, type of inspection, check on product packaging, types of specific tests performed).

- Traceability:

  Description of the yard process to ensure traceability of the materials from the time of the reception to the end of the production operations.

- Hull construction:

  Description of the yard process to ensure that the scantlings and construction meet the rule requirements in relation to the approved drawings.

- Installation of internal structure:

  Information about the main operations of the internal structure installation.

- Equipment:

  The main equipment to be covered by the rules of the Society are portholes, windows and deck hatches, watertight doors, independent tanks and rudders, the scheduled tests and traceability on the equipment upon arrival and/or after installation.

- Testing and damage reference documents:

  For all the previously defined MTI plan processes, procedures are to be written, defining the types of tests or inspections performed, the acceptance criteria and the means of handling non conformities.

5.5 Society's certificate

5.5.1 Certificate of recognition

After completion of the examination, by the Society, of the quality assurance manual, the MTI plan and the yard audit, a Certificate of recognition may be granted as per the provisions of NR320 Classification Scheme of Materials & Equipment, as amended.

5.5.2 Certificate of conformity

Each hull may be certified individually upon request made to the Society.

5.6 Other certification scheme for production in large series

5.6.1 Other certification scheme for production in large series, based on NR320 Classification Scheme of Materials & Equipment may be considered by the Society on a case by case basis.

Part B
Hull and Stability

CHAPTER 6
STRUCTURE DESIGN AND SCANTLING REQUIREMENTS FOR COMPOSITE, PLYWOOD AND HDPE

Section 1 General Requirements and Characteristics of Materials

1 Application

1.1 General

1.1.1 The requirements of the present chapter are applicable to yacht hulls made totally or partly of composite, plywood or HDPE materials.

1.1.2 Attention is drawn to the use of composite, plywood and/or HDPE 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 these materials.

2 Hull scantling analysis approach

2.1 General

2.1.1 As a rule, the local scantling is examined on the basis of local permissible safety factors defined in relation to the type of loads applied and the type of structure elements.

The structure check is to be carried out taking into account the local loads and the global loads (when considered according to Ch 4, Sec 1, [2]) independently.

When deemed necessary by the Society, the hull structure analysis taking into account the global hull girder loads and the local loads may be carried out on a case by case basis.

2.1.2 Scantling criteria

a) Composite or plywood analyzed by a ply by ply approach:

The design review of the local scantling of plating and stiffener consists in checking that the actual safety factors, equal to the ratio between the theoretical breaking stresses of the elementary layers of the laminate and/or the basic element making up the stiffener (flange, web and attached plating) and the actual applied local stresses are greater than the permissible values defined in Ch 6, Sec 3, taking into account the type of load.

The values of the theoretical breaking stresses are defined in the Rule Note NR546 Hull in Composite Materials, Sec 5 [5].

Breaking stresses directly deduced from mechanical tests may be taken over from theoretical breaking stresses defined in the Rule Note NR546 Hull in Composite Materials if mechanical test results are noticeably different from expected values.

b) PEHD or plywood analyzed by a global approach:

The design review of the local scantling of plating and stiffener consists in checking that the applied stresses are greater than the permissible values defined in Ch 6, Sec 3, taking into account the type of load.

3 Composite, plywood and HDPE materials for hull structure

3.1 General

3.1.1 The characteristics of the composite, plywood and HDPE materials are to comply with the applicable requirements of NR546 Hull in Composite Materials in particular for the:

- raw materials analysis
- individual layers and laminate analysis
- stiffener analysis
- principle of hull structure analysis

3.1.2 Raw materials

The general information on the “state of the art” about raw materials considered in the present Rules are defined in the Rule Note NR546 Hull in Composite Materials, Sec 4.

The certification scheme of raw materials is to be as defined the Rule Note NR546 Hull in Composite Materials, Appendix 1.

4 Hull construction survey and testing

4.1 Hull construction survey

4.1.1 Hull construction and survey requirements within the scope of the classification of yachts and/or certification of yacht hulls built in composite, plywood or HDPE materials are defined in NR546 Composite Ships, Sec 12.

The scope of classification is defined in NR467 Rules for Steel Ships, Part A.

4.2 Testing

4.2.1 The pressure testing conditions for tanks, watertight and weathertight structures in order to check the tightness and/or the strength of structural elements are defined in NR600 Ships less than 90 m, Ch 7, Sec 3.

As a rule, these tests are to be carried out for ships surveyed by the Society during construction within the scope of classification.

Section 2 Main Structure Arrangements and Other Structures

1 General

1.1 Application

1.1.1 Main structure arrangements

The main structure arrangement for yacht hull built in composite, plywood or HDPE materials are to be as defined in NR546 Hull in Composite Materials, Section 3.

Additional requirements for yacht as defined in the present section are to be taken into account for bottom, side, deck, bulkheads and superstructure arrangements.

Any other equivalent arrangement may be considered on a case by case basis.

1.1.2 Special features arrangements

Special features such as water jet propulsion tunnel, foils and trim support and lifting appliances are to be as defined in NR546 Hull in Composite Materials, Section 3.

2 Additional requirements for bottom structure arrangements

2.1 Charter yacht carrying more than 12 passengers

2.1.1 **Charter yacht** carrying more than 12 passengers may be considered by the Flag Administration as passenger ship. In such a case, it might be necessary to provide a continuous double bottom satisfying the relevant requirements of NR546 Hull in Composite Materials, Section 3.

2.2 Bottom structure in way of bulb keel of sailing yacht

2.2.1 The bottom structure sustaining the bulb keel of sailing yacht are to be checked by direct calculations taking into account the:

- design loads defined in Ch 7, Sec 7
- safety factors as defined in Ch 6, Sec 3.

2.2.2 Keel bolted to the bottom structure

As a rule, bottom laminate rule scantling calculated according to Ch 6, Sec 5 is to be increased by 50% in case of keel fin bolted to the bottom structure.

2.2.3 Bolts are to be of a high strength type and their scantlings are to be checked according to Ch 7, Sec 7.

3 Additional requirements for side structure arrangements

3.1 Side shell structure in way of sailing yacht chainplates

3.1.1 Local reinforcements are to be provided on the side shell in order to distribute the local loads induced by the chainplates to the side shell structure.

The local reinforcements on the side shell are to be checked by direct calculation taking into account the design loads induced by the chainplates defined in Ch 7, Sec 6.

Chainplates scantling is to be in accordance with Ch 7, Sec 6.

3.1.2 As a general rule, chainplates cannot be directly bonded on sandwich laminate skin and should be provided on a monolithic laminate area of hull.

4 Additional requirements for deck structure arrangements

4.1 Deck structure in way of mast of sailing yacht

4.1.1 When deemed necessary by the Society, the transverse buckling strength of deck in way of mast is to be checked according to NR546 Hull in Composite Materials, Sec 6, [4] taking into account the horizontal transversal compression force induced by the horizontal force component of mast shrouds.

Additionally transverse stiffeners or equivalent arrangement may be requested to reduce the panel size submitted to buckling.

4.1.2 An increase of lamination panel or additional reinforcements may be requested in way of deck openings provided in the area of mast.

5 Cofferdam arrangement

5.1 General

5.1.1 Cofferdams are to be provided between:

- fuel oil tanks and lubricating oil tanks
- compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and compartments intended for fresh water (drinking water, water for propelling machinery and boilers)
- compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and tanks intended for the carriage of liquid foam for fire-extinguishing systems.

5.1.2 Cofferdams separating:

- fuel oil tanks from lubricating oil tanks
- lubricating oil tanks from compartments intended for fresh water or boiler feed water
- lubricating oil tanks from those intended for the carriage of liquid foam for fire-extinguishing systems,

may not be required, when deemed impracticable or unreasonable by the Society in relation to the characteristics and dimensions of the spaces containing such tanks, provided that:

- the scantling check under test load and the structural test are carried out with a head increased by 1 m with respect to Ch 6, Sec 1, [4.2].
- the internal protection of each compartment is to be ensured by suitable protective coating.

6 Additional requirements for superstructures arrangements

6.1 Openings

6.1.1 All openings in superstructure and deckhouse exposed to greenseas are to be fitted with sills or coamings as defined in Ch 2, Sec 2, [3].

The scantling of windows and side scuttles is to be as defined in Ch 7, Sec 3.

6.2 Strengthening of deckhouse in way of tenders and liferafts

6.2.1 Attention is drawn on any possible specific requirement that could be issued by Flag Administration with respect to structural fire protection in way of tenders and liferafts.

7 Other structure

7.1 Strengthening for ice navigation

7.1.1 When requested by the Interested Party, an additional ice class notation **YOUNG ICE 1** or **YOUNG ICE 2** may be assigned according to NR467, Rules for Steel Ships, Pt A, Ch 1, Sec 2.

Hull strengthening required for the assignment of these additional class notations is defined in NR546 Hull in Composite Materials, Sec 3.

7.2 Thruster tunnel

7.2.1 As a rule, the scantling of the thruster tunnel is to be not less than the adjacent hull structure, taking into account the actual spacing and materials.

7.3 Side and stern doors

7.3.1 Door scantling

Scantling of the plates and stiffeners of doors are to be not less than the scantlings of the adjacent side shell.

7.3.2 Securing and supporting structure

Securing arrangement and supporting structure are to be as defined in NR467 Steel Ships, Pt B, Ch 11, Sec 8 [4], taking into account the permissible local stresses for primary stiffeners defined in Ch 5, Sec 3.

A particular attention is to be drawn to the connection between metal devices and composite structure.

7.3.3 Inspection and testing

The requirements of NR467 Steel Ships, Pt B, Ch 11, Sec 8 [5] are applicable.

7.3.4 Type approval procedure

Type approval certificates of doors may be issued to applicant manufacturers as defined in NR467 Steel Ships, Pt B, Ch 11, Sec 8 [6].

7.4 Water jet propulsion tunnel

7.4.1 The drawings of water jet ducts, ship supporting structure, thrust bearing, as well as shell openings and local reinforcements, are to be submitted for examination.

The pressure in water jet ducts, the forces and moments induced by the water jet to the ship structure and the calculation procedure from the designer are to be specified.

In no case the scantlings are to be taken less than the requirements defined in:

- the present Rule Note, for the surrounding hull structure
- NR396 Rules for the Classification of High Speed Craft, Ch 3, C3.9.2. In this case, the minimum rule safety factors to take into account for the structure check, as defined in Ch 5, Sec 3, are to be the same than those considered for the hull bottom structure.

7.5 Foils and trim tab supports

7.5.1 Foils and trim tab supports are not covered within the scope of classification and/or certification.

Forces and moments induced by these elements, as well as the designer calculation, are to be submitted for the examination of the surrounding yacht structure reinforcements.

As a general rule, attachment structure of foils to the yacht structure are to be located within watertight compartment or equivalent.

7.6 Bulwark and guard rails

7.6.1 Scantling of bulwark

a) Plating and secondary stiffeners:

The platings and the secondary stiffeners scantling are to be as defined in Ch 6, Sec 5.

b) Stays:

The scantling of stays is to be checked by direct calculation, taking into account:

- the sea pressure p_s and p_{ssmin} defined in Ch 4, Sec 3
- the bending moment and shear force of the stay in way of the connection with the deck defined in NR546 Hull in Composite Materials Sec 3 [10.2.2]
- the safety factors defined in Ch 6, Sec 3

7.6.2 Scantling of guard rails

The general arrangement and the scantling of guard rails are to be in accordance with the requirements of NR467 Steel Ships Pt B, Ch 12, Sec 2 [3].

Other arrangement may be considered on the basis of designer calculations.

7.7 Lifting appliances

7.7.1 Application

The following requirements are applicable for lifting appliances operated in still water.

As a rule, the lifting appliances operated at sea are to be examined on a case by case considering the ship motions and accelerations defined in the present Rules and requirements defined in NR467 Steel Ships, Pt E, Ch 8, Sec 4.

7.7.2 General

The fixed parts of lifting appliances and their connections to the ship's structure are covered by the present Sub-article, even when the certification (especially the issuance of the Cargo Gear Register) of lifting appliances is not required.

The fixed parts of lifting appliances, considered as an integral part of the hull, are the structures permanently connected to the ship's hull (for instance crane pedestals, masts, king posts, derrick heel seatings, etc., excluding cranes, derrick booms, ropes, rigging accessories, and, generally, any dismountable parts). The shrouds of masts embedded in the ship's structure are considered as fixed parts.

The certification of the lifting appliances may be considered on a case by case basis, at the request of the Interested Party, in accordance with NR526 Rules for the Certification of Lifting Appliances.

7.7.3 Information to be submitted

The following information are to be submitted by the Designer:

- the safe working load (SWL) defined as the maximum static load which may be lifted vertically under normal use within its geometrical limits and the dynamic amplification factors of the lifting equipment self-motions based on the technical standard used for the certification of the lifting equipment
- the general arrangement of the lifting equipment specifying the weight of the main elements (crane body, crane boom…)
- the testing loads
- the forces and moments transmitted by the crane to the ship structure

7.7.4 Checking criteria

Local reinforcements and hull structure surrounding the crane pedestal are to be checked by direct calculations, taking into account the following safety factors:

$SF_{CRANE} = 1,6\ \alpha\ SF$

$SF_{CSCRANE} = 1,6\ \alpha\ SF_{CS}$

where:

SF : Rules safety factor applicable to maximum stress defined in Ch 6, Sec 3, [2.4.3]

SF_{CS} : Rules safety factor applicable to combined stress defined in Ch 6, Sec 3, [2.4.3]

α : Stress factor to be taken as follow:

- $\alpha = 0,6$ for operation case
- $\alpha = 0,9$ for testing case

7.8 Helicopter deck and platform

7.8.1 Deck and platform provided for the landing and takeoff of helicopter are to be examined as defined in NR546 Hull in Composite Materials, Sec 3 [10.3], taking into account arrangement defined in Pt C, Ch 4, Sec 11.

Note 1: The design and arrangement of the helicopter facilities defined in NR600 are based on the Civil Aviation Publication 437 "Offshore Helicopter Landing Areas - Guidance on Standards" (CAP 437)". Upon request of the Interested Party, other standards may be considered by the Society on a case by case basis.

Section 3 Stresses and Safety Factors

1 General

1.1 Application

1.1.1 The requirements of the present section define the permissible safety factors considered for the check of structural members of hull and superstructures of yachts built, totally or partly, in composite, plywood or HDPE materials.

1.2 Global and local stresses

1.2.1 The structure check is to be carried out taking into account the local loads and the global loads (when considered according to Ch 4, Sec 1, [2.2.2]) independently.

When deemed necessary by the Society, the hull structure analysis taking into account the global hull girder loads and the local loads may be carried out on a case by case basis according to the methodology defined in NR546 Hull in Composite Materials.

2 Composite structure

2.1 Principle of design review

2.1.1 The design review of composite structures is based on safety factors which are to be in compliance with the following criteria:

- Minimum stress criteria in layers:

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

- Critical buckling stress criteria:

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

- Combined stress criteria in layers:

$$SF_{CS} \geq SF_{CSiapp}$$

where:

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

σ_c : Critical buckling stress of the composite element considered calculated as defined in NR546, Hull in Composite Materials, Sec 6 [4].

σ_{iapp} : In-plane individual layer applied stresses

σ_A : Compressive stress applied to the whole laminate considered

SF, SF_B , SF_{CS}:Rule safety factors defined in [2.4.3]

SF_{CSiapp} : Actual combined stress safety factor in layer as calculated in NR546 Hull in Composite Materials, Sec 2, [1.3.3].

The breaking stresses directly deduced from mechanical tests (as requested in NR546 Hull in Composite Materials) may be taken over from the theoretical breaking stresses if the mechanical test results are noticeably different from the expected values.

2.2 Types of stress considered

2.2.1 The following different types of stresses are considered, corresponding to the different loading modes of the fibres:

a) Principal stresses in the individual layers:

- Stress σ_1:

  Stress parallel to the fibre (longitudinal direction). These stresses, σ_1, may be tensile stresses or compression 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 σ_2:

  Stress perpendicular to the fibre (transverse direction). These stresses, σ_2, may be tensile stresses or compression stresses, and are mostly located as follows:
  - in 90° direction of unidirectional tape or combined fabrics when the set of fibres are stitched together without criss-crossing

- Shear stresses, τ_{12} (in the laminate plane):

  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 stresses, τ_{13} and τ_{23} (through the laminate thickness):

  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:

- Compression and shear stresses in the whole laminate inducing buckling.

2.3 Theoretical breaking criteria

2.3.1 Three theoretical breaking criteria are considered 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 (see NR546 Hull in Composite Materials)

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

c) critical buckling stress criteria applied to the laminate (see NR546 Hull in Composite Materials).

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.

2.3.2 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".

2.4 Rule safety factors

2.4.1 General

a) General consideration:

The rule safety factors to be considered for the composite structure check are defined in [2.4.3], according to the partial safety factors defined in [2.4.2].

b) Additional considerations:

- General:

  Rule safety factors lower than those defined in [2.4.3] may be accepted for one elementary layer when the other layers of the lay-up laminate exhibits a sufficient safety margin
- Finite element model analysis:

  When the structure is checked with a Finite Element Model, the rule safety factors defined in [2.4.3] and [2.4.4] is to be reduced by ten per cent.

2.4.2 Partial safety factors

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

a) Ageing effect factor C_V

C_V takes into account the ageing effect of the composites and is generally taken equal to:

C_V = 1,2 for monolithic laminates (or for face-skins laminates of sandwich) and strip planking

C_V = 1,1 for sandwich core materials

b) Fabrication process factor C_F

C_F takes into account the fabrication process and the reproducibility of the fabrication and is generally taken equal to:

C_F = 1,10 in case of a prepreg process

C_F = 1,15 in case of infusion and vacuum process

C_F = 1,25 in case of a hand lay-up process and strip planking

C_F = 1,00 for the core materials of sandwich composite

c) Type of load factor C_i

C_i takes into account the type of loads and is generally taken equal to:

C_i = 1,0 for local external sea pressures and internal pressures or concentrated forces

C_i = 0,8 for dynamic sea pressures (slamming loads on bottom) and for test pressures and flooding loads

C_i = 0,6 for impact pressure on side shell and on platform bottom of multihull

d) Type of stress factor C_R

C_R takes into account the type of stress in the fibres of the reinforcement fabrics and the cores and 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:
     C_R = 2,1 for unidirectional tape, bi-bias, three-unidirectional fabric
     C_R = 2,4 for woven roving
   - for tensile or compressive stress perpendicular to the continuous fibre of the reinforcement fabric:
     C_R = 1,25 for unidirectional tape, bi-bias, three-unidirectional fabric
   - for shear stress parallel to the fibre in the elementary layer and for interlaminar shear stress in the laminate:
     C_R = 1,6 for unidirectional tape, bi-bias, three-unidirectional fabric
     C_R = 1,8 for woven roving
   - for mat layer:
     C_R = 2,0 for tensile or compressive stress in the layer
     C_R = 2,2 for shear stress in the layer and for interlaminar shear stress
2) For core materials
   - for tensile or compressive stress for cores:
     - in the general case:
       C_R = 2,1 for tensile or compressive stress
     - for balsa:
       C_R = 2,1 for tensile or compressive stress parallel to the wood grain
       C_R = 1,2 for tensile or compressive stress perpendicular to the wood grain
   - for shear stress, whatever the type of core material:
     C_R = 2,5
3) For wood materials for strip planking
   C_R = 2,4 for tensile or compressive stress parallel to the continuous fibre of the strip planking
   C_R = 1,2 for tensile or compressive stress perpendicular to the continuous fibre of the strip planking
   C_R = 2,2 for shear stress parallel to the fibre and for interlaminar shear stress in the strip planking.

2.4.3 Rule safety factors

The rule safety factors SF, SF_{CS} and SF_B to be considered for the composite structure check are defined according to the type of hull structure calculation, as follows:

a) For structure checked under local loads:
   The local loads considered are defined in Ch 4, Sec 3 and Ch 4, Sec 4:
   1) Minimum stress criterion in layers: $SF = C_V\ C_F\ C_R\ C_i$
      with:
      C_V, C_F, C_R, C_i:Partial safety factors defined in [2.4.2]
   2) Combined stress criterion in layers: $SF_{CS} = C_{CS}\ C_V\ C_F\ C_i$
      with:
      C_{CS} : Partial safety factor, to be taken equal to:
      - C_{CS} = 1,7 for unidirectional tape, bi-bias, three-unidirectional fabric
      - C_{CS} = 2,1 for the other types of layer

      C_V, C_F, C_i: Partial safety factors defined in [2.4.2]

b) For structure element contributing to the global strength checked under global hull girder loads:
   The global hull girder loads considered are defined in Ch 4, Sec 2.
   The minimum stress criterion in layers and the combined stress criterion in layers are to be taken as defined in a) with a value of C_i equal to 1,4.
   The critical buckling stress criterion is to be taken equal to:
   $SF_B = C_{Buck}\ C_V\ C_F\ C_i$
   with:
   C_{Buck} : Partial safety factors to be taken equal to 1,45
   C_V : Partial safety factors to be taken equal to 1,2
   C_i : Partial safety factors to be taken equal to 1,2
   C_F : Partial safety factors defined in [2.4.2]

Note 1: When deemed necessary, buckling check of structure element submitted to local compressive load are to be examined according to b).

c) Particular case:
   Structure element scantling checked taking into account global and local combined stresses are to be examined on a case by case on the basis of NR600 Ch 2, Sec 3.

2.4.4 Rule safety factor for structural adhesive joints

The mechanical structural adhesive characteristics are to be as defined in NR546 Hull in composite materials, Sec 4 [5].

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

a) General case:

$SF \geq 2,4\ C_t C_v C_F C_{t°} C_i$

Taking into account the following partial safety factors:

C_t : Value discrepancies of the shear breaking stresses determined by mechanical tests, to be taken equal to 1,2

C_v : Ageing effect, to be taken equal to 1,2

Note 1: When the joint is exposed to UV and/or to sea water, a greater value of C_v is to be considered on the basis of test.

C_F : Factor taking into account the gluing process (with final control defined on a case by case basis) and generally taken as follows:

- $C_F = 1,15$ in case of a vacuum or infusion process
- $C_F = 1,25$ in case of manual process

$C_{t°}$:
- When the adhesive joint is tested in laboratory for the different ranges of temperature provided in service: $C_{t°} = 1$
- When the characteristics of the adhesive joint for the different ranges of temperature provided in service are extrapolated from technical datasheets of the adhesive supplier: $C_{t°} = 1,2$

C_i : Partial safety factor defined in [2.4.2].

b) For joint of minor importance, the failure of which might induce only localised effect:

$SF \geq 2,0\ C_t C_v C_F C_{t°} C_i$

Taking into account the following partial safety factors:

C_t : As defined in a) or, when the shear breaking stress are determined on the basis of datasheets for appropriate adherents, to be taken equal to 1,5

C_v : As defined in a)

C_F : As defined in a) or when provided without final control, to be taken equal to:

- $C_F = 1,3$ in case of a vacuum or infusion process
- $C_F = 1,5$ in case of manual process

$C_{t°}$: As defined in a)

C_i : Partial safety factor defined in [2.4.2].

3 Plywood structure

3.1 Principle of design review

3.1.1 Characteristics of plywood

The mechanical characteristics of plywoods are to be estimated as defined in NR546 Hull in Composite Materials.

3.1.2 Principle of design review

The design review of plywood structure is based on one of the two following methods as defined in NR546 Hull in Composite Materials:

- global approach, when mechanical characteristics of plywood are defined, or
- ply by ply approach, based on the same calculation process than composite.

For each method, the safety factors (defined as the ratio between the applied stresses, calculated on the basis of the present rules, and the theoretical breaking criteria of the plywood or elementary layers of the plywood) are to be greater than the minimum rule safety factors defined in [2.2].

3.2 Minimum rule safety factors

3.2.1 Global plywood approach

As a general rule, the minimum permissible safety factors S_F to take into account in the global formula used to determined the thickness of plating or the permissible stress in stiffener is to be at least greater than 4,0.

3.2.2 Ply by ply approach

As a general rule, the rule safety factor SF applicable to the maximum stress in each layer of the plywood is to be calculated as follows:

a) Minimum stress criterion in layers:

$SF = C_R C_i C_V$

with:

C_R : Factor taking into account the type of stress in the grain of the plywood layer. Generally:

- C_R = 3,7 for a tensile or compressive stress parallel to the grain of the ply considered
- C_R = 2,4 for tensile or compressive stress perpendicular to the grain of the ply considered
- C_R = 2,9 for a shear stress

C_i : Factor taking into account the type of loads. Generally:

- C_i = 1,0 for local external sea pressures and internal pressures or concentrated forces
- C_i = 0,8 for dynamic sea pressures (slamming loads on bottom, impact on flat bottom in forward area), and for test pressures and flooding loads
- C_i = 0,6 for impact pressure on side shell and on platform bottom of multihull

C_V : Factor taking into account the ageing effect of the plywood, to be taken at least equal to 1,2

b) Critical buckling stress criterion

As a general rule, the rule safety factor SF_B applicable to the critical buckling stress criterion is to be calculated as follows:

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

with:

C_{Buck} , C_V : Partial safety factors, to be taken equal to 1,35 and 1,2 respectively for the check of the global hull girder structure

C_i : Partial safety factor to be taken equal to 1,2.

4 HDPE structure

4.1 Principle of design review

4.1.1 Characteristics of HDPE

The mechanical characteristics of HDPE are to be estimated as defined in NR546 Hull in Composite Materials, Sec 10.

4.1.2 Principle of design review

The review of hull structure built in HDPE is to be carried out as defined in NR546 Hull in Composite Materials, Sec 10.

4.2 Rule permissible stresses

4.2.1 The permissible stresses for the check of structure are defined in Tab 1.

Table 1 : Permissible stresses

Loading cases	Structure element	Stress	Permissible value
Local sea and internal pressures	Plating	σ_{locam}	0,45 R
	Secondary stiffener	σ_{locam}	0,50 R
		τ_{locam}	0,30 R
	Primary stiffener	σ_{locam}	0,55 R
		τ_{locam}	0,30 R
		σ_{vmam}	0,55 R
Local dynamic sea pressure: • bottom slamming for planing hull • side shell impact	Plating	σ_{locam}	Bottom slamming: 0,75 R Side shell impact: 0,85 R
	Secondary stiffener	σ_{locam}	Bottom slamming: 0,70 R Side shell impact: 0,90 R
		τ_{locam}	Bottom slamming: 0,40 R Side shell impact: 0,50 R
	Primary stiffener **(1)**	σ_{locam}	0.85 R
		τ_{locam}	0,45 R
		σ_{vmam}	0,85 R

Note 1:

R : Tensile strength at yield of the HDPE, in Mpa, as defined in NR546 Hull in Composite materials, Sec 10

σ_{locam} , τ_{locam} :Permissible local stresses, in N/mm², in relation to the type of loads and element

σ_{vmam} : Permissible local Von Mises equivalent stresses, in N/mm², in relation to the type of loads for primary stiffeners

SF_{buck} : Buckling safety coefficient to be considered when the global hull girder strength is examined as required in NR546 Hull in Composite materials, Sec 10.

(1) Not applicable for side shell impact analysis

Loading cases	Structure element	Stress	Permissible value
Flooding loads	Plating	σ_{locam}	0,50 R
	Secondary stiffener	σ_{locam}	0,55 R
		τ_{locam}	0,30 R
	Primary stiffener	σ_{locam}	0,55 R
		τ_{locam}	0,30 R
		σ_{vmam}	0,55 R
Testing loads	Plating	σ_{locam}	0,60 R
	Secondary stiffener	σ_{locam}	0,65 R
		τ_{locam}	0,35 R
	Primary stiffener	σ_{locam}	0,70 R
		τ_{locam}	0,40 R
		σ_{vmam}	0,70 R
Global loads according to NR546 Hull in Composite Materials, Sec 10 [1.2.2] and [3.3]	All structure elements	SF_{buck}	1,3

Note 1:
R : Tensile strength at yield of the HDPE, in Mpa, as defined in NR546 Hull in Composite materials, Sec 10
σ_{locam} , τ_{locam} :Permissible local stresses, in N/mm², in relation to the type of loads and element
σ_{vmam} : Permissible local Von Mises equivalent stresses, in N/mm², in relation to the type of loads for primary stiffeners
SF_{buck} : Buckling safety coefficient to be considered when the global hull girder strength is examined as required in NR546 Hull in Composite materials, Sec 10.
(1) Not applicable for side shell impact analysis

Section 4 Global Hull Girder and Platform Scantling

1 General

1.1 Application

1.1.1 The global strength analysis is to be carried out when deemed necessary as defined in Ch 4, Sec 1, [2.2.2] in order to check the hull girder stresses in relation to the:

- global hull girder loads defined in Ch 4, Sec 2, and
- the minimum stress and combined stress criteria in layers, and the buckling criteria defined in Ch 6, Sec 3, [2.4.3].

1.2 Global strength calculation

1.2.1 Global strength for monohull

The overall longitudinal bending strains ε_A in % and stresses σ_A, in N/mm², in any point of a transverse reference section are obtained as defined in NR546 Hull in Composite Materials, Sec 2, [4.2.2], where M_v are the overall bending moments defined in Ch 5, Sec 4, [2.2] or Ch 5, Sec 4, [2.3].

1.2.2 Global strength for catamaran

- The global strength analysis of catamaran yacht is to be carried out taking into account:
  - the basic beam model defined in Ch 5, Sec 4, [3.3] with the transverse cross deck and float considerations defined in NR546 Hull in Composite Materials Sec 2 [5.2.2] and [5.2.3], and
  - the elementary loading cases defined in Ch 5, Sec 4, [3.4] or Ch 5, Sec 4, [3.5],
- Transverse cross structures (under mast and mainsail sheet) and fore cross beam are to be examine as defined in Ch 5, Sec 4, [3.5.3].

The overall bending strains ε_A in % and stresses σ_A in N/mm² in the float and in transverse cross beams and bulkheads are deduced from the beam model calculation according to NR546 Hull in Composite Materials, Sec 2 [5.2.5].

1.2.3 Global strength analysis by finite element calculation

The global strength analysis defined [1.2.1] and [1.2.2] may also be carried out by a Finite Elements Analysis submitted by the designer.

In this case, the structural model, the global loads distribution and the boundary conditions are to fulfill the general requirements defined in Ch 5, Sec 4, [4.2] and Ch 5, Sec 4, [4.3].

1.3 Scantling criteria

1.3.1 Panel and stiffener analysis

The rule analysis of panels and stiffeners under global loads is to be carried out as defined in NR546 Hull in Composite Materials, Sec 6 [7] and Sec 7 [6] respectively.

1.3.2 Safety factors

a) General case:

   The rule safety factors to take into account are defined in Ch 6, Sec 3, [2.4.3].

b) Finite element calculation:

   When the global strength analysis is carried out by a Finite Elements Analysis according to [1.2.3], the safety factors defined in a) may be reduced by 10%.

2 Analysis of laminate panel sustaining global loads

2.1 General

2.1.1 The requirements of the present article are given for information.

2.1.2 Laminate panel sustaining global loads are to be examined taking into account the:

- maximum and combined stresses in each layers, and
- critical buckling stress in the whole panel for panels submitted to compression.

The buckling check of the laminate panels are based on the following hypothesis:

- for monolithic laminate: all laminate edges are supposed simply supported in way of the laminate supports
- for sandwich laminate: all laminate edges are supposed clamped in way of the laminate supports.

Note 1: For sandwich laminate, only global buckling is taken into account. Buckling modes such as shear crimping, local face dampling, face wrinkling... are considered as not usual with type of sandwich used in the construction of yacht.
When deemed necessary, other buckling mode than global buckling may be examined.

2.1.3 The hull areas to be checked for laminate panel sustaining global loads are:
For compression and tensile global loads:

- bottom and decks panel
- side shell panel, in the upper area below strength deck
- deck area around mast of sailing yachts (in the transversal direction of the hull)
- bottom and deck panels of platform of catamarans, in way of transverse primary bulkheads.

For shear global loads:

- hull side shells.
- primary transverse bulkheads of catamarans.

3 Analysis of stiffeners sustaining global loads

3.1 General

3.1.1 The requirements of the present article and given for information.

3.1.2 Stiffeners sustaining global loads are to be checked taking into account the compression and tensile forces applied in its plane induced by global loads.
The different elements of the stiffeners (attached plate, web and flange) are to be checked taking into account:

- the maximum and combined stresses in each layers of the different elements
- the critical buckling stress in the different elements.

3.1.3 The hull areas to be checked for stiffeners sustaining global loads are:
For longitudinal stiffeners:

- bottom and decks stiffeners
- side shell stiffeners submitted to global hull bending

For transversal stiffeners:

- bottom and deck stiffeners of the platform of catamarans, in way of transverse primary bulkheads
- deck stiffeners around mast of sailing yachts.

3.2 General arrangement of stiffeners

3.2.1 The general arrangement of stiffeners of bottom, side, deck, bulkhead and superstructure is to be as defined in the present section together with NR546 Hull in Composite Materials,Sec 3.

Section 5 Hull Structure Scantling under Local Loads

1 General

1.1 Material

1.1.1 The structure scantling check under local loads of monohull and multihull is to be carried out according to the present Section and NR546 Hull in Composite Materials.

1.2 Local scantling considerations

1.2.1 Application

The present section deals with the local scantling of plating, secondary and primary stiffeners under lateral pressures and are to be considered together with NR546 Hull in Composite Materials.

The scantling of plating and ordinary and primary stiffeners contributing to the overall longitudinal strength of the hull girder and to the overall transversal strength of platform of catamaran are also to be checked as defined in Ch 6, Sec 4.

1.3 Local load point location

1.3.1 Sea pressure

Unless otherwise specified, the sea pressure is to be calculated:

- for plate panel: at the lower edge of the plate panel for monolithic panel, plywood or HDPE panel and at mid edge for sandwich panel
- for longitudinal stiffener: at mid-span of the stiffener
- for transversal stiffener: at the lower point ($p_{S\ lower}$) and at the upper point ($p_{S\ upper}$) of the stiffener.

1.3.2 Dynamic sea pressures

Unless otherwise specified, the dynamic sea pressure is to be calculated:

- for plate panel: at the mid edge of the plate panel
- for longitudinal and transversal stiffener: at mid-span of the stiffener.

2 Plating scantling

2.1 General

2.1.1 Local plating scantling are to be designed under the several following loading:

- for bottom platings: Sea pressure and bottom slamming pressure (if applicable)
- for side shell and bottom platform platings: Sea pressure and side shell impact
- for deck and superstructure platings: The greater value of sea pressure and minimum loads.
- for tanks: local internal pressure and testing loads
- for watertight bulkheads fitted for damage stability: flooding loads.

2.2 Scantling of plating made of composite

2.2.1 The scantling of composite plating is to be checked according to:

- the calculation methodology defined in NR546 Hull in Composite Materials, Sec 6 [5]
- the local loads defined in Ch 4, Sec 3 and Ch 4, Sec 4.

2.2.2 The safety factors to take into account are defined in Ch 6, Sec 3.

2.2.3 Analysis of laminate panel sustaining local loads (for information)

a) Laminate panel sustaining local loads are to be examined taking into account the maximum and combined stresses in each layers.

The laminate panels are examined by calculating on the four sides of the panel the bending moments and the shear forces induced by the lateral local loads defined in Ch 4, Sec 3 and in Ch 4, Sec 4.

Each side of the laminate panel is considered as clamped.

b) The bending moments and shear forces at each side of the panel are calculated according to the methodology defined in NR546 Hull in Composite Materials, Section 6.

Two main calculation approaches of bending moment and shear force are defined taking into account the type of local loads:

- case of local uniform loads: wave loads and bottom slamming loads (considered as uniform loads)
- case of impact pressure on side shell: load locally distributed like a water column of 0,6 m diameter and applied at the middle of the panel.

c) A particular attention is to be paid on the effect, on the laminate panel bending moments, of the width of stiffener of omega type.

The factors $k_{s,x}$ and $k_{s,y}$ defined in NR546 Hull in Composite Materials, Sec6 [5.1.4] taking into account this effect, may noticeably reduce the values of the bending moments on the laminate panel.

d) Laminate panel stresses are to be checked (layer by layer) according to NR546 Hull in Composite Materials, Sec 6 taking into account the values of the main and secondary bending moments, and the shear forces.

2.3 Scantling of plating made in plywood

2.3.1 The scantling of plywood structure is based on one of the two following methods as defined in NR546 Hull in Composite Materials, Sec 9:

- global approach, when mechanical characteristics of plywood are defined, or
- ply by ply approach, based on the same calculation process than composite.

2.3.2 The safety factors to take into account are defined in Ch 6, Sec 3, [3].

2.4 Scantling of plating made in HDPE

2.4.1 The scantling of HDPE structure is based on the methodology defined in NR546 Hull in Composite Materials, Sec 10.

2.4.2 The permissible stresses to take into account are defined in Ch 6, Sec 3, [4].

3 Ordinary stiffener scantling

3.1 General

3.1.1 Loading cases

Local ordinary stiffener scantling are to be designed under the several following loading:

- for bottom stiffeners: Sea pressure and bottom slamming loads (if applicable)
- for side shell and bottom platform stiffeners: Sea pressure and side shell impact
- for deck and superstructure stiffeners: The greater value of sea pressure and minimum loads.
- for tank stiffeners: local internal pressure and testing loads
- for stiffeners on watertight bulkheads fitted for damage stability: flooding loads.

Note 1: As a general rule, side shell primary stiffeners and bottom platform primary stiffeners are examined with sea pressure only, without taking into account the side shell impacts.

3.1.2 Calculation parameters

The span of the stiffeners and their degrees of freedom at ends are to be considered as defined in NR546 Hull in composite materials, Sec 7.

3.2 Scantling of ordinary stiffener made in composite

3.2.1 The scantling of composite ordinary stiffener is to be checked according to:

- the calculation methodology defined in NR546 Hull in Composite Materials, Sec 7
- the local loads defined in Ch 4, Sec 3 and Ch 4, Sec 4.

3.2.2 The safety factor to take into account are defined in Ch 6, Sec 3.

3.3 Scantling of ordinary stiffener made in plywood

3.3.1 The scantling of plywood ordinary stiffener is to be checked according to:

- the calculation methodology defined in NR546 Hull in Composite Materials, Sec 9
- the local loads defined in Ch 4, Sec 3 and Ch 4, Sec 4.

3.3.2 The safety factor to take into account are defined in Ch 6, Sec 3.

3.4 Scantling of ordinary stiffener made in HDPE

3.4.1 The scantling of HDPE structure is based on the methodology defined in NR546 Hull in Composite Materials, Sec 10.

3.4.2 The permissible stresses to take into account are defined in Ch 6, Sec 3, [4].

3.5 General arrangement of ordinary stiffeners

3.5.1 The general arrangement of ordinary stiffeners of bottom, side, deck, bulkhead and superstructure is to be as defined in the present section together with NR546 Hull in Composite Materials, Section 3.

3.5.2 As a general rule, the lamination between ordinary web and primary web is to be at least equivalent to the web lamination of the secondary stiffener.

3.5.3 The principle of bracket arrangement is to be based as defined in NR546 Hull in composite materials, Sec 7 [7].

3.6 Analysis of ordinary stiffeners sustaining local loads

3.6.1 The requirements of the present Sub-article are given for information.

3.6.2 The width of the attached plating to be considered for the check of secondary stiffeners and for the calculation of its geometrical characteristics is to be obtained, in m, from the following formula:

- where the attached plating extends on both sides of the stiffener:

  $b_P = \min (s; 0,2\ell)$

- where the attached plating extends on one side of the stiffener (i.e. stiffener bounding openings):

  $b_P = \min (0,5s; 0,1\ell)$

where:

s : Spacing, in m, of the secondary or primary stiffener under consideration

ℓ : Span, in m, as defined in NR546 Hull in Composite Materials, Section 7, of the secondary or primary stiffener under consideration.

3.6.3 Stiffener sustaining local loads are to be examined taking into account the maximum and combined stresses in each layers of the different elements of the stiffener (attached plate, web and flange).

The stiffeners are examined by calculating the bending moment and shear forces induced by the lateral local loads.

Special attention is to be paid to the connection of stiffeners and surrounding supporting structure. A scantling coefficient “m”, taking into account the end conditions of the stiffener, is to be considered as defined in NR546 Hull in Composite Materials, Sec 7, [4].

Note 1: Attention is to be particularly paid on the location where the strains are calculated to take into account which basic element of the stiffener (attached plating or flange) is in tensile or in compression.

3.6.4 The bending moments and shear forces applied to the stiffener are calculated according to the methodology defined in NR546 Hull in Composite Materials, Sec 7, [3], taking into account [3].

Two main calculations approach of bending moment and shear force are defined in NR546 Hull in Composite Materials:

- case of local uniform loads: wave loads and bottom slamming loads (considered as uniform loads)
- case of impact pressure on side shell: load locally distributed like a water column of 0,6 m diameter and applied at the middle of the panel.

4 Primary stiffener scantling

4.1 General

4.1.1 Primary stiffener scantling are to be designed under the several following loading:

- for primary bottom stiffeners: Sea pressure and bottom slamming loads (if applicable)
- for primary side shell stiffeners: Sea pressure
- for primary deck and superstructure stiffeners: The greater value of sea pressure and minimum loads.
- for tank primary stiffeners: local internal pressure and testing loads
- for primary stiffeners on watertight bulkheads fitted for damage stability: flooding loads.

4.2 Primary stiffeners scantling

4.2.1 Isolated beam calculation

a) General:

   As a rule, the primary stiffeners scantling is to be carried out as defined in [3.2] or in [3.3] for primary stiffener analysed by an isolated beam calculation.

For deck primary structure exposed to sea pressure, the loads considered for the scantling may be reduced by the following coefficients:

- 0,8 for primary structure of exposed superstructure decks
- $(1 - 0{,}05\ell) > 0{,}8$ for primary structure of exposed decks.

b) Curvate primary stiffener:

The curvature of primary supporting members may be taken into account by direct analysis (see [4.2.2] c).

4.2.2 Two- or three-dimensional structural model

a) General:

When an isolated beam calculation of the primary structure is not possible due to an interaction of the primary stiffeners, a two- or three- dimensional structural model is to be considered as defined in Ch 5, Sec 5, [4.3.2] (see also NR546, Sec 7 [10]).

b) Sefety factors:

The rule safety factors to take into account are defined in Ch 6, Sec 3, [2.4.3].

c) Curvate primary stiffener:

The curved primary supporting members are to be represented by a number N of straight beams, N being adequately selected to minimize the spring effect in way of knuckles.

The stiffness of knuckles equivalent springs is considered as minor from the local bending moment and shear forces distribution point of view where the angle between two successive beams is not more than 3°.

4.2.3 Finite element model

a) General:

The structural model, the local loads distribution and the boundary conditions of the model are to fulfill the general requirements defined in Ch 5, Sec 5, [4.4.2] and Ch 5, Sec 5, [4.4.3].

b) Safety factors:

When the primary stiffener strength analysis is carried out by a Finite Elements Analysis, the rule safety factors to take into account are defined in Ch 6, Sec 3, [2.4.3] reduced by 10%.

4.3 General arrangement of primary stiffeners

4.3.1 Scantling of brackets of primary stiffeners are to be examined as defined in NR546 Hull in composite materials, Sec 7.

4.3.2 Stiffener connection with attached plating

Stiffener connections with attached plating are to be considered as defined in NR546 Hull in composite materials, Sec7.

4.3.3 The web shear area of primary supporting members is to take into account the section reduction due to cut-outs provided for the ordinary stiffeners passage through the primary supporting members, if relevant.

It may be necessary to increase the primary web lamination in way of the secondary stiffener to ensure the continuity of the shear strength of the primary web.

4.3.4 In general, the depth of cut-outs in the web member is to be not greater than 50% of the depth of the primary supporting member.

4.3.5 Where openings such as duct for pipes, electrical cable..., are provided in primary supporting members, they are to be equidistant from the face plate and the attached plate. As a rule, their height is not to be more than 20% of the primary supporting member web height.

4.3.6 Cut out in web may not be fitted in way of end brackets and, as a general rule, in area where the shear forces are maximum.

4.3.7 Over half of the span in the middle of the primary supporting members, the length of openings is to be not greater than the distance between adjacent openings.

At the ends of the span, the length of openings is to be not greater than 25% of the distance between adjacent openings.

4.3.8 All openings carried out in stiffener are to be protected against damage caused by water and/or humidity by one or more laminate product laminated on the opening edges.

4.3.9 Local secondary bending effect can be induced when large openings are provided in primary supporting members. In this case, the arrangement of these openings and the scantling criteria are to be examined as defined in NR546 Hull in Composite Materials, Section 7.

5 Calculation principles for gluing structure connections

5.1 General

5.1.1 Gluing structure connections are adhesive joints where structure elements are bonded by placing a layer of adhesive or resin system between the structure elements.

As a rule, adhesive structure connections are examined by direct calculation taking into account the shear force applied to the adhesive joints, the surface of the joint, the gluing joint characteristics as defined in NR546 Hull in composite materials Sec 4 [5] and the safety factor defined in Ch 6, Sec 3.

Where gluing structure connection are submitted to tension or out of plane forces (cleavage, peel...) due to the joint geometry, or where adhesive with shear elongation at break greater than 10% are used, the gluing structure connection is to be examined on a case by case basis.

6 Pillars

6.1 Pillar scantling

6.1.1 The scantling check of pillars under axial loads is to be examined as defined in NR546 Hull in Composite Materials Sec 8, taking into account the safety factors defined in Ch 6, Sec 3.

6.1.2 Masts loads for sailing yacht

For sailing yachts, when the mast is sustained by a pillar, the compression axial load F_M in the pillar is to be obtained, in kN, from the following formula:

$$F_M = a_v P_M + F_C + F_A$$

where:

P_M : Weight, in KN, of the mast

F_C : Compressive force, in KN, induced by the standing rigging

F_A : Compression axial deck loads to be taken equal to:

$$F_A = A_D p_s + \sum_i r Q_i$$

where:

A_D : Area, in m², of the portion of the deck or the platform supported by the pillar considered

p_s : Pressure on deck, in kN/m², as defined in Ch 4, Sec 4, [1]

r : Load factor depending on the relative position of each pillar above the one considered, to be taken equal to:

- $r = 0,9$ for the pillar immediately above the pillar considered
- $r = 0,9^i > 0,478$ for the i^{th} pillar of the line above the pillar considered

Q_i : Vertical local load, in kN, supported by the i^{th} pillar of the line above the pillar considered, if any.

a_v : Vertical acceleration, expressed in g, to be taken not less than:

- for monohull: As defined in Ch 4, Sec 3, [4.2.4]
- for multihull: 1,3

Note 1: When masts are located on the floats of multihull, the value of the vertical aceleration a_v is to be considered on a case by case basis.

The values of P_M and F_C are to be defined by the designer.

CHAPTER 7
HULL OUTFITTINGS

Section 1 Equipment in Anchors and Chain Cables

1 General

1.1 Design assumptions for anchoring equipment

1.1.1 The requirements of the present Section only apply to temporary mooring of yacht within a harbour or sheltered area, where the yacht is awaiting for berth, tide, etc.

1.1.2 The equipment complying with these requirements is not designed to hold a yacht off fully exposed coast in rough weather nor for stopping the yacht which is moving or drifting. In these conditions the loads on anchoring equipment increase to such a degree that its components can be damaged or lost.

1.1.3 Where frequent anchoring in open sea is expected, the attention of the Interested Party is drawn to the fact that anchoring equipment should be provided in excess to the requirements of this Rules.

1.1.4 The equipment complying with the requirements in [3] is intended for holding a ship in good holding sea bottom, where the conditions are such as to avoid dragging of the anchor. In poor holding sea bottom, the holding power of the anchors is to be significantly reduced.

1.1.5 Equipment in anchors and cables may be reduced on a case-by-case basis. Nevertheless, it belongs to designer and/or shipyard to submit all the relevant information demonstrating that reduced equipment - its configuration - and all its components, fully copes with the mooring forces most frequently encountered during service.

1.1.6 For yachts of special design or for yachts engaged in special services or on special voyage, the Society may consider anchoring equipment other than defined in the present Section.

1.1.7 Anchors and mooring line components - chain cable and its accessories, wire rope, etc. - are to be manufactured in accordance with relevant requirements of NR216 Materials and Welding.

1.1.8 The bow anchors, connected to their own chain cables, are to be so stowed as to always be ready for use. Other arrangements of equivalent provision in security and safety may be foreseen, subjected to Society's agreement.

Note 1: Towline not covered by the present rule may be requested by Flag administration.

2 Anchoring equipment calculation

2.1 General

2.1.1 All yachts are to be provided with equipment in anchors and chain cables (or cable and ropes) within the scope of classification. This equipment is determined from the dynamic forces due to wind and current acting on the yacht in conditions as defined in [1].

2.1.2 The determination of the anchoring equipment for yachts having the navigation notation **unrestricted navigation**, **navigation limited to 60 nautical miles** or **coastal area** is based on following assumptions:

- wind speed of 38 knots (19,6 m/s)
- current speed of 5 knots (2,5 m/s)
- the water depth for mooring is approximately between one tenth and one sixth of the chain cable length calculated according to [3.2.2]
- the yacht uses one anchor only under normal circumstances.

2.1.3 The determination of the anchoring equipment for yachts having a navigation notation **sheltered area** is to be based on the following assumption:

- wind speed of 30 knots (15,5 m/s)
- current speed of 5 knots (2,5 m/s)

2.1.4 For **charter yacht** intended to carry more than 12 passengers, Flag authorities may request that the equipment may be determined as defined in NR467 Rules for Steel Ship.

2.1.5 The equipment in anchor and chain cable is to be considered on a case by case basis by the Society when the dynamic force acting on the yacht as defined in [2.2.1] is greater than 50 KN.

In this case, the requirements defined in NR600 Rules for ships less than 90 m Ch 5, Sec 4 may be considered instead of the present Section.

2.1.6 A different equipment of anchor and chain cables may be considered on a case by case with the agreement of the Interested Party. In this case, a note is entered in a memoranda.

2.2 Anchor mooring force calculation for monohull

2.2.1 Dynamic force F_{EN}

a) Dynamic force

The dynamic force, in KN, induced by wind and current acting on monohull in mooring condition as defined in [2.1.2] may be calculated as follow:

$F_{EN} = 2\ (F_{SLPH} + F_{SH} + F_{SS}) + 1{,}3\ F_m$

where:

F_{SLPH} : Static force on wetted part of the hull due to current, as defined in [2.2.2]

F_{SH} : Static force on hull due to wind, as defined in [2.2.3]

F_{SS} : Static force on superstructure due to wind, as defined in [2.2.4]

F_m : Static force on mast and standing rigging due to wind, as defined in [2.2.5].

b) Minimum value of the dynamic force

As a rule, the dynamic force F_{EN} is to be taken greater than:

- 1,0 KN for yachts having the navigation notation **sheltered area**
- 2,2 KN for yachts having another service notation.

2.2.2 Static force on wetted part of hull F_{SLPH}

The theoretical static force induced by current applied on the wetted part of the hull, in KN, is defined according to the following formula:

$$F_{SLPH} = \frac{1}{2}\rho C_f S_m V_c^{\ 2} 10^{-3}$$

where:

ρ : Water density, equal to 1025 kg/m^3

C_f : Coefficient equal to:

$$C_f = (1+k)\frac{0,075}{(\log R_e - 2)^2}$$

Where:

R_e : Reynolds number equal to $V_c.L_{WL}/1{,}054.10^{-6}$

k : Coefficient equal to:

$$k = 0,017 + 20\frac{C_b}{L_{WL}^{\ 2} \cdot T^{-0.5} \cdot B_{WL}^{\ -1.5}}$$

S_m : Total wetted surface of the part of the hull under full load draught, in m^2

The value of S_m is to be given by the designer. When this value is not available, S_m may be taken equal to $6\Delta^{2/3}$

V_c : Speed of the current, in m/s, as defined in [1].

2.2.3 Static force on hull F_{SH}

The theoretical static force induced by wind applied on the upper part of the hull, in KN, is defined according the following formula:

$$F_{SH} = \frac{1}{2}\rho(C_{hfr}S_{hfr} + 0,2S_{har} + 0,02S_{hlat})V_w^{\ 2}10^{-3}$$

where:

ρ : Air density, equal to 1,22 kg/m^3

V_w : Speed of the wind, in m/s, as defined in [1]

S_{hfr} : Front surface of hull and bulwark if any, in m^2, projected on a vertical plane perpendicular to the longitudinal axe of the yacht

S_{har} : Aft hull transom surface and bulwark if any, in m^2, projected on a vertical plane perpendicular to the longitudinal axe of the yacht

S_{hlat} : Partial lateral surface of one single side of the hull and bulwark if any, in m^2, projected on a vertical plane parallel to the longitudinal axe of the yacht and delimited according Fig 1

C_{hfr} : Coefficient equal to 0,8 sinα, where α is defined in Fig 1

Note 1: In Fig 1, B is the breath of the hull, in m.

Note 2: The upper part of the hull is the part extending from side to side to the uppermost continuous deck extending over the ship length.

2.2.4 Static force on superstructure F_{SS} and deckhouses

The theoretical static force induced by wind applied on the superstructures and deckhouses, in KN, is defined as the sum of the forces applied to each superstructure and deckhouse tier according the following formula:

$$F_{SS} = \frac{1}{2}\rho\Sigma(C_{sfri}S_{sfri} + C_{sari}S_{sari} + 0,08S_{slati})V_w^{\ 2}10^{-3}$$

where:

ρ : Air density, equal to 1,22 kg/m³

V_w : Speed of the wind, in m/s, as defined in [1]

S_{sfri} : Front surface of tier i (superstructure or deckhouse, including bulwark if any), in m², projected on a vertical plane perpendicular to the longitudinal axe of the yacht

S_{sari} : Aft surface of tier i (superstructure or deckhouse, including bulwark if any), in m², projected on a vertical plane perpendicular to the longitudinal axe of the yacht

S_{slati} : Partial lateral surface of one single side of tier i (superstructure or deckhouse, including bulwark if any), in m², projected on a vertical plane parallel to the longitudinal axis of the ship and delimited according to Fig 1.

When $4h_i \geq \ell_{si}$, S_{lati} is to be taken equal to 0.

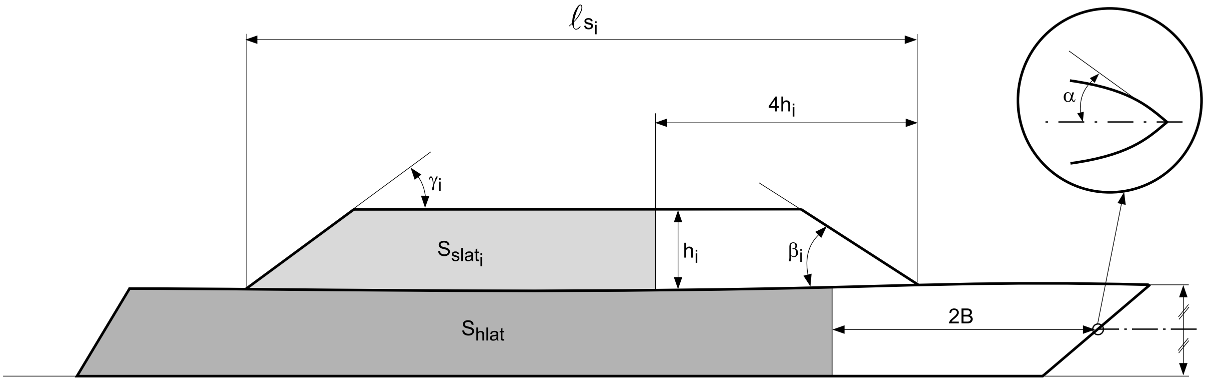
C_{sfri} : Coefficient of tier i equal to 0,8 $\sin\beta_i$, where β_i is defined in Fig 1

C_{sari} : Coefficient of tier i equal to:

- If $h_i/\ell_{si} \geq 5,00$ $\quad C_{sari} = 0,7\sin\gamma_i$
- If $5 \geq h_i/\ell_{si} \geq 0,25$ $\quad C_{sar} = 0,5\sin\gamma_i$
- If $h_i/\ell_{si} \leq 0,25$ $\quad C_{sar} = 0,3\sin\gamma_i$

where h_i, ℓ_{si} and γ_i are defined in Fig 1 for each tier.

Figure 1 : Hull and superstructure surface calculation



2.2.5 Static force on standing rigging F_m

For sailing yachts, the theoretical static force induced by wind applied on the standing rigging, in KN, is defined according the following formula for each mast:

$$F_m = \frac{1}{2}\rho\left(C_{xm}h_m b_m + C_{xi}\sum \ell_i d_i 10^{-3}\right)V_w^{\ 2}10^{-3}$$

where:

ρ : Air density, equal to 1,22 kg/m³

V_w : Speed of the wind, in m/s, as defined in [1]

C_{xm} : Mast or rotor sail drag coefficient to be taken equal to (see Note 1):

- 0,5 for cylindrical mast or rotor
- 0,22 for streamlined mast or wing mast.

h_m : Height, in m, of the mast

b_m : Breadth, in m, of the mast

C_{xi} : Shroud drag coefficient to be taken equal to 1,2 (see Note 1).

ℓ_i : Length, in m, of mast shrouds (lower and upper, fore and backstay)

d_i : Diameter, in mm, of shrouds or sail furled if applicable.

For sailing yacht having several masts, the total static force induced by wind applied on the standing rigging is to be taken equal to the sum of the forces F_m of each mast and its standing rigging.

Note 1: Other drag coefficient may be taken into account if duly justified.

Note 2: Attention is drawn to the fact that Flag authorities may require another approach to determine the equipment in chain and anchors for sailing charter yachts.

2.3 Anchor mooring force calculation for catamaran

2.3.1 The dynamic force, in KN, induced by wind and current acting on catamaran in mooring condition as defined in [2.1.2] may be calculated as defined in [2.2] with the following particular assumptions for the calculation of the static forces on:

- Wetted part of the hull F_{SLPH} : As defined in [2.2.2], taking into account the two floats to calculate the total wetted surface S_m
- Hull F_{SH} : As defined in [2.2.3] taking into account:
  - The two floats for the calculation of S_{hfr}
  - The two floats transom and the aft surface of the aft transversal main beam between the floats for the calculation of S_{har}
  - One single side of one float for the calculation of S_{hlat} ("B" as defined in Fig 1 is to be taken as the breath of one float).
- Superstructure F_{SS}: As defined in [2.2.4] taking also into account the frontal surface of the platform of catamaran.

3 Equipment in chain and anchor

3.1 Anchors

3.1.1 Mass of individual anchor

The individual mass of anchor, in Kg, is to be at least equal to:

- $P = (F_{EN} / 7) .10^2$ for ordinary anchor,
- $P = (F_{EN} / 10) .10^2$ for high holding power anchor,
- $P = (F_{EN} / 15) .10^2$ for very high holding power.

3.1.2 Number of anchors

The number of anchors for anchoring mooring to be provided on board is to be at least:

- One anchor, when the dynamic force F_{EN} calculated according to [2.2], is less than 4,5 KN,
- Two anchors, when the dynamic force F_{EN} calculated according to [2.2], is greater than 4,5 KN.

Note 1: For yachts with F_{EN} between 4,5 and 9,0 kN, the second anchor may be dispensed. In this case, the weight of the anchor and the length and size of the chain cable are to be calculated according to [3.1.1], [3.2.1] and [3.2.2], considering F_{EN} increased by one third.

Attention is drawn to the fact that Flag authorities may require two anchors for charter yachts.

When two anchors are required, the weight of the second anchor, in kg, may be calculated according [3.1.1] taking into account a dynamic force F_{EN} as defined in [2.2] reduced by 30%.

3.1.3 Anchor design and performance tests

Anchors are to be from an Approved Type. Therefore, Holding power - performance - assessment, Design review and Tests and examination on manufactured product are to be carried-out.

Anchors are to have appropriate shape and scantlings in compliance with Society requirements. Moreover, they 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 sea bottom.

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 a Type Approved ordinary stockless anchor of the same mass.

Holding power is to be assessed by full-scale comparative tests.

For very high holding power anchors, the holding power test load is to be less than or equal to the proof load of the anchor, specified in NR216 Materials and Welding, Ch 10, Sec 1, [1.5].

Comparative tests on Type Approved 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 sea bottom. Three are the types of sea bottoms in which tests are to be performed, e.g. soft mud or silt, sand or gravel and hard clay or similar compounded.

The pull is to be measured by means of a dynamometer; measurements based on the bollard pull against propeller's revolutions per minute curve may be accepted instead of dynamometer readings.

Anchor stability and its ease of dragging are to be noted down, whenever possible.

Upon satisfactory outcome of the above tests, the Society will issue a certificate declaring the compliance of high or very high holding power anchors with its relevant Rules.

3.1.4 Manufacturing, materials, test and examination

Manufacturing and materials are to comply with relevant requirements of NR216 Materials and Welding.

Tests and examination requirements are to comply with NR216 Materials and Welding, Ch 10, Sec 1, [1.5].

3.2 Chain cables

3.2.1 Chain cable scantling

Chain cable diameter, type and steel grades are to be as defined in Tab 1, according to the minimum breaking BL and proof loads PL, in KN, defined according to the following formulae:

- For steel grade Q_1:

  $BL = 3,6\ F_{EN}$

  $PL = 0,7\ BL$

- For steel grade Q_2:

  $BL = 4,0\ F_{EN}$

  $PL = 0,7\ BL$

- For steel grade Q_3:

  $BL = 4,5\ F_{EN}$

  $PL = 0,7\ BL$

- For steel grade SL, chain cable diameter is to be determined according Tab 2 on the basis of proof loads defined for steel grade Q.

The chain cable scantling is to be consistent with the mass of the associated anchor. In case the anchor on board is heavier by more than 7% from the mass calculated in [3.1.1], the value of F_{EN} to take into account in the present Article for the calculation of BL and PL is to be deduced from the actual mass of the anchor according to the formulae in [3.1.1].

3.2.2 Length of individual chain cable

The length of chain cable L_{cc}, in m, linked to anchor is to be at least equal to:

$L_{cc} = 30.\ \ln(P) - 42$

where:

ln(P) : Neperian logarithm of the anchor weight, in kg, defined in [3.1.1] for an ordinary anchor.

The minimum length of chain on board is to be in accordance with the water depth of anchoring specified in [2.1.2].

3.2.3 Number of chain cable

When two chain cables are required according to [3.1.2], the length of the second chain cable, in m, may be calculated according [3.2.2] taking into account an equipment number as defined in [2.2] reduced by 30%.

Table 1 : Proof and breaking loads for stud link chain cables (quality Q)

Chain diameter (mm)	Grade Q1		Grade Q2		Grade Q3		Minimum mass per meter length (kg/m)
	Proof load (KN)	Breaking load (KN)	Proof load (KN)	Breaking load (KN)	Proof load (KN)	Breaking load (KN)	
11	36	51	51	72	72	102	2,7
12,5	46	66	66	92	92	132	3,6
14	58	82	82	115	115	165	4,4
16	75	107	107	150	150	215	5,7
17,5	89	128	128	180	180	255	6,7
19	105	150	150	210	210	300	7,9
20,5	123	175	175	244	244	349	9,1
22	140	200	200	280	280	401	10,5
24	167	237	237	332	332	476	12,4
26	194	278	278	389	389	556	14,5
28	225	321	321	449	449	649	16,7
30,0	257	368	368	514	514	735	19,2

Table 2 : Proof and breaking loads for studless link chain cable (quality SL)

Chain diameter (mm)	Grade SL1		Grade SL2		Grade SL3		Minimum mass per meter length (kg)
	Proof load (KN)	Breaking load (KN)	Proof load (KN)	Breaking load (KN)	Proof load (KN)	Breaking load (KN)	
6	6,5	13	9	18	13	26	0,8
8	12	24	17	34	24	48	1,4
10	18,5	37	26	52	37	74	2,4
11	22,5	45	32	64	45	90	2,7
12,5	29	58	41	82	58	116	3,5
14,5	39	78	55	110	78	156	4,6
16	47,5	95	67	134	95	190	5,6
17,5	56,5	113	80	160	113	226	6,8
19	67	134	95	190	134	268	7,9
20,5	78	156	111	222	156	312	9,3
22	90	180	128	256	180	360	10,6
24	106	212	151	302	212	424	12,7
25,5	120	240	170	340	240	480	14,3
27	135	270	192	384	270	540	16,1
28,5	150	300	213	426	300	600	17,9
30	166	332	236	472	332	664	19,8

3.2.4 Chain cables arrangements

Chain cables made of grade Q1or SL1 may not be used with high holding power and very high holding power anchors.

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.

Test and examination requirements are to comply with NR216 Materials and Welding, Ch 10, Sec 1.

3.2.5 Studless link chain cable

For yachts with F_{EN} less than 18 kN, studless short link chain cables may be accepted by the Society as an alternative to stud link chain cables, provided the equivalence in strength is determined according to Tab 2 on the basis of proof loads defined for steel grade Q in [3.2.1].

3.2.6 Wire ropes and synthetic fibre ropes

When two chain cables are required according to [3.1.2], as an alternative to the second chain cable, wire ropes or synthetic fibre ropes may be used for yachts length less than 40 m.

The ropes are to have a length equal to 1,5 times the chain cable length as calculated in [3.2.2].

A short length of chain cable having scantlings complying with [3.2.1] is to be fitted between the rope and the bow anchor. The length of this chain part is not to be less than 12,5 m or the distance from the anchor to its stowed position to the windlass, whichever is the lesser.

As a rule, fibre ropes are to be made of polyamide or other equivalent synthetic fibres, excluding polypropylene.

The effective breaking load P_R, in kN, of the rope is to be not less than the following value:

- $P_R = BL$ for wire rope
- $P_R = 1,2\ BL$ for synthetic fibre rope,

where BL, in kN, is the required breaking load defined in [3.2.1] of the replaced chain cable.

All surfaces being in contact with the wire need to be rounded with a radius of not less than 10 times the wire rope diameter (including stem).

3.2.7 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.

4 Shipboard fittings for anchoring equipment

4.1 General

4.1.1 Chain breaking load value

In the present Article, the value of the breaking load of the chain to be considered for the determination of the brake capacity of the windlass, the pull capacity of the chain stopper and the scantling of deck reinforcements is to be taken equal to the breaking load of the chain actually provided on board.

4.1.2 As a rule, the design, construction and testing of windlasses and chain stopper are to comply with NR626 Anchor Windlass and Chain Stoppers.

4.2 Windlass

4.2.1 Brake capacity

Based on mooring line arrangements with brakes engaged and cable lifter disengaged, the capacity HL (Holding Load), in kN, of the windlass brake is to be sufficient to withstand the following design loads without any permanent deformation of the stressed parts and without brake slip:

- 0,8 time the breaking load of the chain if not combined with a chain stopper
- 0,45 time the breaking load of the chain if combined with a chain stopper.

4.3 Chain stopper

4.3.1 Chain stopper

A chain stopper is generally 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. The chain stopper is to comply with applicable requirements given in the Rule Note NR626 Anchor Windlass and Chain Stoppers. As a rule, the chain stopper is to be able to withstand a pull of 80% of the breaking load of the chain, without any permanent deformation of the stressed parts.

Chain tensioners or lashing devices supporting the weight of the anchor where housed in the anchor pocket are not to be considered as chain stoppers.

4.4 Deck reiforcements

4.4.1 Deck reinforcement under windlass and chain stopper

Local reinforcement of deck structure is to be provided in way of windlass and chain stopper, and designed in accordance with:

a) Windlass

   Brake capacity as defined in [4.2.1], associated to:

   - for steel and aluminium structure: a permissible stress equal R_{eH} or R'_{lim}
   - for composites materials structure: safety coefficient as defined in Ch 6, Sec 3.

b) Chain stopper

   Design load as defined in [4.3.1], associated to:

   - for steel and aluminium structure: a permissible stress equal to R_{eH} or R'_{lim}
   - for composites materials structure: safety coefficient as defined in Ch 6, Sec 3.

4.5 Chain locker

4.5.1 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 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% 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.

5 Shipboard fitting for towing and mooring

5.1 General

5.1.1 The equipment for mooring and/or towing is not covered within the scope of classification.

However, hull deck reinforcement under mooring and towing equipment such as, bitts, bollard, fairleads, chocks... are to be examined within the scope of hull drawing examination.

The arrangement, design loads and allowable stresses to be considered are to be as defined in NR467 Steel Ships, Pt B, Ch 12, Sec 4 [4.2].

The breaking loads used to determine the maximum design load applied to shipboard fittings are based on an Equipment Number EN given in NR467 Steel Ships, Pt B, Ch 12, App 2 [2]. This equivalent Equipment Number EN is to be taken equal to 4,7 times the value of F_{EN} as calculated in [2.2.1] with a side project area S_{hlat} including deck cargoes.

5.1.2 Documents to be submitted

Maximum safe working loads and breaking loads of equipment used for the mooring and the towing are to be specified.

A mooring and towing arrangement plan is to be submitted to the Society for information. This plan is to define the method of use the mooring and towing lines and to include the equipment location on the deck, the fitting type, the safe working and breaking loads and the manner of applying mooring and towing lines (including line angles).

When the mooring plan is not available, the equipment such as bitts and bollards (when the line may come and go from the same direction) are to be loaded up to twice their safe working loads

Section 2 Rudder Stock and Rudder Blade

1 General

1.1 Application

1.1.1 General

The requirements of this Section apply to ordinary profile rudders, without any special arrangement for increasing the rudder force, whose maximum orientation at maximum ship speed is limited to 35° on each side.

In general, an orientation greater than 35° is accepted for manoeuvres or navigation at very low speed.

The arrangement of the steering gear is to be as defined in Pt C, Ch 1, Sec 3.

1.1.2 High efficiency rudders

The requirements of this Section also apply to rudders fitted with flaps to increase rudder efficiency. For these rudder types, an orientation at maximum speed different from 35° may be accepted. In these cases, the rudder forces are to be calculated by the Designer for the most severe combinations between orientation angle and ship speed. These calculations are to be considered by the Society on a case-by-case basis.

The rudder scantlings are to be designed so as to be able to sustain possible failures of the orientation control system, or, alternatively, redundancy of the system itself may be required.

1.1.3 Reference system

The system of axis reference is considered as follow (see Fig 1):

- X axis: longitudinal axis aligned with chord of the rudder profile
- Y axis: transversal axis perpendicular to XZ plan
- Z axis: vertical axis aligned with Z axis from reference co-ordinate system of the Yacht.

1.2 Arrangement

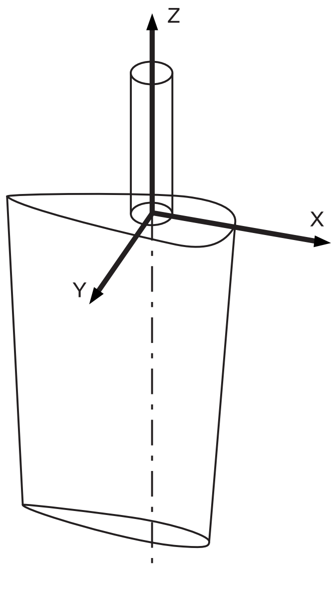
1.2.1 Effective means are to be provided for supporting the weight of the rudder without excessive bearing pressure, e.g. by means of a rudder carrier attached to the upper part of the rudder stock. The hull structure in way of the rudder carrier is to be suitably strengthened.

1.2.2 Suitable arrangements are to be provided to prevent the rudder from lifting.

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, as detailed in Pt C, Ch 1, Sec 3, [3].

1.2.3 In rudder trunks which are open to the sea, a seal or stuffing box is to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier. If the top of the rudder trunk is below the deepest waterline two separate stuffing boxes are to be provided.

Figure 1 : Reference system



1.3 Materials

1.3.1 Rudder made of steel

Rudder stocks, pintles, coupling bolts, keys and cast parts of rudders are to be made of rolled steel, steel forgings or steel castings according to the applicable requirements in NR216 Materials and Welding, Chapter 3.

The requirements relevant to the determination of scantlings contained in this Section apply to steels having a minimum yield stress equal to 235 N/mm^2.

Where the material used for rudder stocks, pintles, coupling bolts, keys and cast parts of rudders has a yield stress different from 235 N/mm^2, the scantlings calculated with the formulae contained in the requirements of this Section are to be modified, as indicated, depending on the material factor k_1, to be obtained from the following formula:

$$k_1 = \left(\frac{235c}{R_{eH}}\right)^n$$

where:

R_{eH} : Minimum yield stress, in N/mm^2, of the specified steel, and not exceeding the lower of 0,7 R_m and 450 N/mm^2

R_m : Minimum ultimate tensile strength, in N/mm^2, of the steel used

n : Coefficient to be taken equal to:

- $n = 0,75$ for $R_{eH} > 235$ N/mm^2
- $n = 1,00$ for $R_{eH} \leq 235$ N/mm^2.

c : Material factor taken equal to:

- 1 for steel elements
- 0,9 for stainless steel or other materials elements non affected by corrosion.

Significant reductions in rudder stock diameter due to the application of steels with yield stresses greater than 235 N/mm^2 may be accepted by the Society subject to the results of a check calculation of the rudder stock deformations (refer to [3.3.4]).

1.3.2 Rudder made of aluminium

The material factor k_1 to take into account for rudder elements in aluminium alloys is to be taken equal to:

$$k_1 = \frac{0,9 \cdot 235}{R'_{lim}}$$

where:

R'_{lim} : Minimum yield stress of the aluminium alloys considered, to be taken equal to the minimum value, in welded condition, between $R'_{p0,2}$ (proof stress) and 0,7 R'_m (tensile strength), where $R'_{p0,2}$ and R'_m are defined in NR561 Aluminium Ships.

In the non-welded areas, R'_{lim} may be taken equal as defined here above in non welded condition on a case by case basis.

1.3.3 Rudder made of composite

Composite materials for rudder stocks, and rudder plates, are to comply with the requirements of NR546 Hull in Composite Materials.

The scantlings of the parts of rudder made in composite materials are to be checked according to [5].

1.4 Documents to be submitted

1.4.1 Following drawings and documents are to be submitted for examination by the Society:

- rudder arrangement including location of rudder stock, bearings, pintles, rudder carrier, and steering gear (design speed V to be specified)
- rudder blade structure including details of pintles, bearings, stiffening, connection to rudder stock
- rudder horn if any
- for all component of the rudder system types of materials and their mechanical characteristics are to be specified.

2 Forces and moments acting on the rudder

2.1 Rudder force

2.1.1 The rudder force C_R, in N, acting on the blade is to be calculated according to NR467 Steel Ships, Pt B, Ch 12, Sec 1 [2.1.2], taking into account a speed V equal to 0,85 V_{AV} or 0,85 V_{AD}, depending on the condition under consideration, where:

V_{AV} : Maximum ahead service speed, in knots, with the ship on summer load waterline; if V_{AV} is less than 10 knots, the maximum service speed is to be taken not less than the value obtained from the following formula:

$$V_{MIN} = \frac{V_{AV} + 20}{3}$$

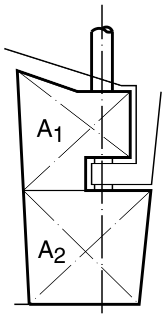
V_{AD} : Maximum astern speed, in knots, to be taken not less than 0,5 V_{AV}.

2.2 Rudder torque

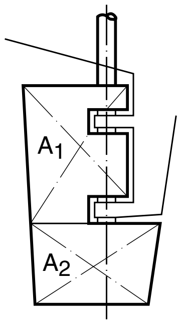
2.2.1 The rudder torque M_{TR}, in N.m, is to be obtained as defined in NR467 Steel Ships, Pt B, Ch 12, Sec 1 [2.1.3], taking into account the rudder force C_R as defined in [2.1.1]:

- [2.1.3] for rudder blade having trapezoidal or rectangular contour,
- [2.2.3] for rudder blade with cut-outs as shown in Fig 2.

Figure 2 : Rudder blades with cut-outs



Trapezoidal rudder blade
Semi-spade rudder with
rudder horn - 2 bearings



Trapezoidal rudder blade
Semi-spade rudder with
rudder horn - 3 bearings

2.3 Rudder bending moments and shear forces

2.3.1 The rudder bending moments M_{Bi}, in N.m, applied to the rudder are to be obtained as defined in NR467 Steel Ships, Pt B, Ch 12, App 1 in relation to the type of rudder defined in Tab 1, taking into account the rudder force C_R defined in [2.1.1].

3 Steel and aluminium rudder scantling

3.1 General

3.1.1 The scantling of the different parts of the rudder are to be examined according to the loads and requirements defined in Tab 1

Table 1 : Relevant loads and requirements

Item	Relevant loads
Rudder stock scantlings	• either torque only, or • both, torque and bending moment (See [3.3])
Rudder stock couplings	• either torque only, or • both, torque and bending moment (See [3.4])
Rudder stock bearings	Horizontal reaction forces, F_{Ai}, (See [3.7])
Pintle bearings	Horizontal reaction forces, F_{Ai}, (See [3.7])
Scantling of pintles	Horizontal reaction forces, F_{Ai}, (See [3.5])
Rudder blade scantlings	Bending moment and shear force (See [4])
Rudder horn scantlings	Bending moment, shear force and torque (See [3.8])
Solepiece scantlings	Bending moment and shear force (See [3.8])

3.2 Arrangement

3.2.1 Suitable tapering is to be carried out in case of significant change in the cross section of rudder stock, to avoid hard points. Abrupt changes in cross section of rudder stock may be accepted by Society on case by case basis.

3.2.2 Tiller or quadrant is to be fitted as far as practicable, such in a way that they will not induce secondary moment or reaction in the rudder stock. If any, bending moment and torque, are to be corrected for the calculation of rudder stock scantling (see [3.3.3] b).

3.3 Rudder stock

3.3.1 The rudder stock diameter is to be not less than the value obtained, in mm, from the following formula:

a) Rudder stock area subjected to torque and bending:

$$d_{TF} = 4(M_{TR}\,k_1)^{1/3}\left[1+\frac{4}{3}\left(\frac{M_B}{M_{TR}}\right)^2\right]^{1/6}$$

b) Rudder stock area subjected to torque only:

$$d_T = 4\,(M_{TR}\,k_1)^{1/3}$$

where:

M_B, M_{TR} : Maximum absolute value of torque and bending moments and torque moment over the rudder stock length, to be obtained according [2.2] and [2.3].

k_1 : Material factor defined in [1.3.1] for steel and in [1.3.2] for aluminium

3.3.2 Rule rudder stock diameters in way of bearings

The rudder stock diameters are to be not less than the value obtained in:

- [3.3.1] a): in way of the lower bearing
- [3.3.1] b): in way of the upper beating

3.3.3 Rule rudder stock diameter in way of the tiller

a) General case:

In general, the diameter of a rudder stock subjected to torque and bending may be gradually tapered above the lower stock bearing so as to reach, from d_{TF} value, the value of d_T in way of the quadrant or the tiller.

b) Particular case:

When the steering gear system is located between the lower and upper bearings (main or autopilot system), and provided to apply the torque moment to the rudder stock by a system using one tiller arm only or a quadrant, the rudder stock diameter in way of the tiller is to be calculated according to [3.3.1] a), taking into account a bending moment M_B, in Nm, equal to:

$$M_B = M_{Bi} + M_{sg}$$

where:

M_{Bi} : Bending moment, in Nm, calculated as defined in [2.3.1] in way of the tiller

M_{sg} : Secondary bending moment, in Nm, induced by the force applied to the tiller arm or the quadrant equal to:

$$M_{sg} = F.a.b/\ell$$

F : Force, in N, applied to the tiller arm to transmit the torque moment, and taken equal to M_{TR}/L

L : Distance, in m, between the point of application of the force F to the rudder stock axis

a : Distance, in m, between the tiller to the lower rudder stock bearing

b : Distance, in m, between the tiller to the upper rudder stock bearing

ℓ : $\ell = a + b$

3.3.4 Rudder stock slope in way of bearings

Large rudder stock deformations are to be avoided in order to avoid excessive edge pressures in way of bearings.

The Society may require an additional check of the rudder stock diameter to make sure that the rudder stock slopes in way of bearings are acceptable, by relating them to bearing lengths and bearing clearances (see NR467 Steel Ships, Pt B, Ch 12, Sec 1 [6.2.3] and [6.2.4]).

3.3.5 Equivalent stresses

The equivalent stresses to check the rudder stock scantling are:

- Area subject to torque and bending:

  σ_E : Equivalent stress, in N/mm², to be obtained from the following formula:

  $$\sigma_{E,\,ALL} = \sqrt{\sigma_B^2 + 3\tau_T^2} = 133/k_1$$

- Area subjected to torque only:

  τ_{ALL} : Allowable torsional shear stress, in N/mm²:

  $$\tau_{ALL} = 75\,/\,k_1$$

where:

k_1 : Material factor defined in [1.3.1] for steel and in [1.3.2] for aluminium

3.4 Rudder stock coupling

3.4.1 Coupling between rudder stock and rudder blade

a) General:

The different types of coupling between rudder stock and rudder blade are to be examined according to NR467 Steel Ships as defined in Tab 2 and taking into account the following particular symbols:

d_1 : Rudder stock diameter, in mm, defined in [3.3.1]a)

d_T : Rudder stock diameter, in mm, defined in [3.3.1]b)

k_{1S}, k_{1F} : Material factor of rudder stock and flange to be taken equal to k_1 as defined in [1.3.1] for steel and [1.3.2] for aluminium alloys

k_{1B} : Material factor of bolts to be taken equal to k_1 as defined in [1.3.1]

R_{eH} : Minimum yield stress, in N/mm² to be taken equal to R_y as defined in Ch 5, Sec 1

The other symbols not listed here above are to be taken as defined in the requirements defined in Tab 2.

b) Coupling by continuous rudder stock welded to the rudder blade:

When the rudder stock extends throughout the rudder blade, the web flanges provided to apply the torque moment induced by the rudder blade and their welding to the rudder stock are to be examined by direct calculation.

Each web flange is to be loaded by a torque moment equal to:

$M_T = M_{TR} / n$

where:

M_{TR} : Rudder torque calculated according to [2.2]

n : Number of web flanges provided to apply the torque moment induced by the rudder blade to the rudder stock

The permissible stresses are to be as considered in [3.3.5].

c) Cone coupling for rudder in aluminium alloys are to be examined on a case by case basis.

Table 2 : Rules requirement references for rudder stock coupling

Type of coupling	Rules requirement references
Horizontal flange	NR467 Pt B, Ch 12, Sec 1 [5.1]
Vertical flange	NR467 Pt B, Ch 12, Sec 1 [5.4]
Cone	NR467 Pt B, Ch 12, Sec 1 [5.3]
Rudder stock welded to the upper plate of the rudder	NR467 Pt B, Ch 12, Sec 1 [5.5]

3.4.2 Coupling between rudder stock and steering gear

a) Arrangement:

Coupling of rudder stock and tillers could be made by key or by flat areas on rudder stock in way of tiller or quadrants.

The tillers or quadrants are to be efficiently tightened on the rudder stock by means such as:

- bolting (split or two half tillers)
- tapered connecting on steel rudder stock
- cylindrical connecting with shrink fit on steel rudder stock.

The requirements of this sub-article apply in addition to those specified in Pt C, Ch 1, Sec 3, [2].

b) Coupling made by key:

As a rule, this type of system is only allowed on metallic solid rudder stock.

As a rule, keys are to be fitted in way of a tiller or quadrants or a reinforced parts of the tiller or quadrant boss.

The ends of the keyways in the rudder stocks and in the tiller or quadrant are to be rounded and corners at the bottom of the key way are to be provided.

The key is to be embedded at half thickness in the metallic solid rudder stock.

Material constituting the key is to be such as his yield stress is not less than that of the rudder stock and that of tiller or quadrant.

As a rule, stresses induced either by rudder blade or steering gear on the key are to comply with the following formula:

$$\tau_{ALL} > \frac{M_{TR}}{d_T \cdot S_K} \cdot 10^3$$

where:

τ_{ALL} : Allowable shear stress, in N/mm², of key material to be taken not less than $70/k_1$

M_{TR} : Torque, in N.m, as defined in [2.2.1]

d_T : Diameter, in mm, of rudder stock calculated as defined in [3.3.1]b)

S_K : Surface, in mm², subject to shear force of the key.

c) Cone coupling:

For coupling between rudder stock and tillers or quadrants made with conic arrangement, requirements of NR467 Rules for Steel Ships, Part B, Ch 12 Sec 1, [5.2] are to be checked, taking into account a torque moment M_{TR} calculated according to [2.2.1].

Cone coupling for rudder in aluminium alloys are to be examined on a case by case basis.

d) Other coupling systems:

Other type of couplings between rudder stock and tiller may be accepted by the Society on a case by case basis, provided relevant justification is submitted.

3.5 Pintle scantling

3.5.1 The pintle scantlings are to be examined according to NR467 Steel Ships, Pt B, Ch 12, Sec 1 [6.4] with support forces acting on the pintle F_{Ai} calculated according to [2.1] and k_1 as defined in [1.3].

3.6 Rudder trunk

3.6.1 When fitted, the rudder trunck structure is to be examined according to NR467 Steel Ships, Pt B, Ch 12, Sec 1 [5.6] taking into account the following symbols:

C_R : Rudder force as defined in [2.1.1]

d_1 : Rudder stock diameter, in mm, defined in [3.3.1]a)

k : Material factor k_1 for the steel used for the rudder trunk as defined in [1.3] to be taken not less than 0,7

3.7 Rudder stock and pintle bearings

3.7.1 Rudder stock bearings

The rudder stock bearings are to be examined according to NR467 Steel Ships, Pt B, Ch 12, Sec 1 [6.2] with support forces acting on the rudder stock bearings F_{Ai} calculated according to [2.1].

According to the case defined in [3.3.3]b), the forces acting on the rudder stock bearings is to be calculated as follow:

- for the upper bearing: $F_{Ai} + F.a/\ell$
- for the lower bearing: $F_{Ai} + F.b/\ell$

where:

F, a, b and ℓ:As defined in [3.3.3]b)

3.7.2 Pintle bearings

The pintle bearings are to be examined according to NR467 Steel Ships, Pt B, Ch 12, Sec 1 [6.3] with support forces acting on the pintle F_{Ai} calculated according to [2.1].

3.8 Rudder horn and solepiece scantlings

3.8.1 The rudder horn and solepiece scantlings are to be examined according to NR467 Steel Ships, Pt B, Ch 12, Sec 1 [8] taking into account:

- the forces F_{Ai} calculated according to [2.1] for the calculation of bending moment, shear forces and torque acting on the rudder horn
- material factor k_1 as defined in [1.3].

3.9 Steering nozzle

3.9.1 The scantling of steering nozzles are to be examined according to NR467 Steel Ships, Pt B, Ch 12, Sec 1 [10] taking into account a material factor k equal to k_1 as defined in [1.3].

3.10 Azimuth propulsion system

3.10.1 The azimuth propulsion systems are to be examined according to NR467 Steel Ships, Pt B, Ch 12, Sec 1 [11] taking into account a material factor k equal to k_1 as defined in [1.3].

4 Rudder blade scantlings

4.1 General

4.1.1 Application

The requirements of the present article apply to streamlined rudders or to single plate rudders.

4.1.2 Rudder blade structure

The structure of the rudder blade is to be such that stresses are correctly transmitted to the rudder stock and pintles.

For metallic rudder blade, horizontal and vertical web plates are to be provided. Horizontal and vertical webs acting as main bending girders of the rudder blade are to be suitably reinforced.

4.1.3 Access openings

Streamlined rudders, including those filled with pitch, cork or foam, are to be fitted with plug-holes and the necessary devices to allow their mounting and dismounting.

Access openings to the pintles are to be provided. If necessary, the rudder blade plating is to be strengthened in way of these openings.

The corners of openings intended for the passage of the rudder horn heel and for the dismantling of pintle or stock nuts are to be rounded off with a radius as large as practicable.

Where the access to the rudder stock nut is closed with a welded plate, a full penetration weld is to be provided.

4.1.4 Connection of the rudder blade to the trailing edge and nose for rudder blade area

On metallic rudder, where the rudder blade area is greater than 6 m^2, the connection of the rudder blade plating to the trailing edge is to be made by means of a forged or cast steel fashion piece, a flat or a round bar.

For composite rudder, where the rudder blade area is greater than 3 m^2, reinforcements of the trailing edge, made by laminate are provided (e.g. unidirectional tapes).

4.2 Rudder blade

4.2.1 Global strength scantling

For the generic horizontal section of the rudder blade, it is to be checked that the stresses, in N/mm², induced by the loads defined in [2.3], are in compliance with the following formulae:

$\sigma \le \sigma_{ALL}$

$\tau \le \tau_{ALL}$

$\sigma_E \le \sigma_{E,ALL}$

where:

σ : Bending stress, in N/mm², induced by loads

τ : Shear stress, in N/mm², induced by loads

σ_E : Von Mises combined stress, in N/mm², obtained from the following formula:

$$\sigma_E = \sqrt{\sigma^2 + 3\tau^2}$$

σ_{ALL} : Allowable bending stress, in N/mm², specified in Tab 3

τ_{ALL} : Allowable shear stress, in N/mm², specified in Tab 3

$\sigma_{E,ALL}$: Allowable equivalent stress, in N/mm², specified in Tab 3.

Table 3 : Allowable stresses for rudder blade scantlings

Type of rudder blade	Allowable bending stress σ_{ALL} in N/mm²	Allowable shear stress τ_{ALL} in N/mm²	Allowable equivalent stress $\sigma_{E,ALL}$ in N/mm²
Without cut-outs	$110 / k_1$	$50 / k_1$	$120 / k_1$
In way of the recess for rudder horn pintle on semi-spade rudder (see Fig 2)	$75 / k_1$	$50 / k_1$	$100 / k_1$
k_1 : Material factor defined in [1.3.1] for steel and in [1.3.2] for aluminium			

4.2.2 Local plating scantling for streamlined rudder blade

As a rule, rule thickness of metallic plates sustaining lateral pressure is given, in mm, by the formula:

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

where:

μ : Aspect ratio coefficient of the elementary plate panel, equal to:

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

ℓ : Longer side, in m, of the elementary plate panel s : Smaller side, in m, of the elementary plate panel

σ_{am} : Rule permissible stress, in N/mm², equal to:

$\sigma_{am} = 0,6\ R$

R : Minimum yield stress, in N/mm², as defined in Ch 5, Sec 3

p : Pressure, in kN/m², acting on rudder blade to be calculated with the following formula:

$$p = 10 \cdot T + \frac{C_R}{A} \cdot 10^{-3}$$

C_R : Rudder force, in N, as defined in [2.1]

T : Full load draught, in m, as defined in Ch 1, Sec 2, [2.6]

A : Total area of the rudder blade, in m².

The thickness of the top and bottom plates of the rudder blade is to be taken as the maximum of:

- the thickness t_F defined in [4.2.2], calculated with the relevant values of s and ℓ, for both the top and bottom plates
- 1,2 times the thicknesses obtained for the attached side platings around the top and bottom plates, respectively, calculated according to [4.2.2], calculated with the relevant values of s and ℓ

Where the rudder is connected to the rudder stock with a coupling flange, the thickness of the top plate which is welded in extension of the rudder flange is to be not less than the flange coupling defined in [3.4.1] a).

4.2.3 Webs and stiffeners scantling for streamlined rudder blade

a) Web scantling:

As a rule, the web thickness (excepted for top and lower rudder web) is to be at least 70% of that required for rudder plating.

The scantlings of the horizontal and vertical webs are to be sufficient to transmit to the rudder stock and pintles bending and torque moment and the shear forces defined in [2].

When the rudder blade is connected to the rudder stock by an horizontal flange coupling, the upper horizontal web thickness is to be design to be shear resistant to the torque moment defined in [2.2].

b) Secondary stiffener scantling:

Secondary stiffeners scantling are to be in accordance with Ch 5, Sec 5, [3.3.2] taking into account the pressure, in N/m² defined in [4.2.2].

c) Welding:

The welded connections of blade plating to vertical and horizontal webs are to be in compliance with the applicable requirements of NR216 Materials and Welding.

Where the welds of the rudder blade are accessible only from outside of the rudder, slots on a flat bar welded to the webs are to be provided to support the weld root, to be cut on one side of the rudder only.

d) Specific arrangement:

Rudder designed with a solid part in forged or cast steel are to be examined as defined in NR467 Rules for Steel Ships, Part B, Ch 12, Sec 1, [7.4].

4.2.4 Scantling of single plate rudders blade

The present requirements are applicable to single rudder blade as shown on Fig 3.

a) Rudder blade thickness:

The rudder blade thickness, in mm, is to be not less than the value obtained from the following formula:

$$t_B = (1,5sV_{AV} + 2,5)\sqrt{k_1}$$

where:

s : Spacing of stiffening arms, in m, as shown on Fig 3.

k_1 : Material factor defined in [1.3.1] for steel and in [1.3.2] for aluminium

b) Horizontal arms:

The thickness of the arms is to be not less than the blade thickness.

The section modulus of the section of horizontal arm in way of the rudder stock is to be not less than the value obtained, in cm³, from the following formula:

$Z_A = 0,5\ s\ C_H^2\ V_{AV}^2\ k_1$

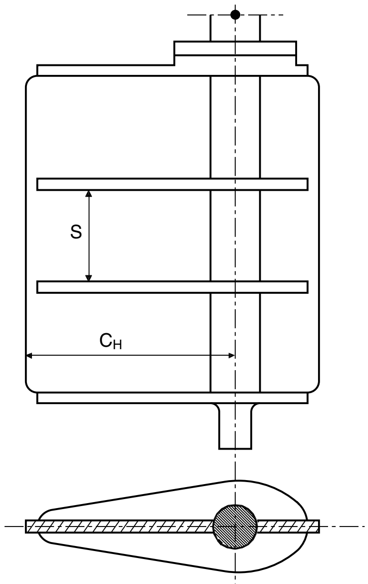
where:

s, C_H : Distance, in m, as defined in Fig 3

V_D : Design speed to be taken in forward speed condition.

k_1 : Material factor defined in [1.3.1] for steel and in [1.3.2] for aluminium

Figure 3 : Single plate rudder



c) Main piece diameter

As a rule, the vertical mainpiece diameter of the rudder blade is to be not less than the rudder stock diameter.

When the vertical mainpiece is tapered or is not continuous until the lower part of the rudder blade (in case of rudder type 6 for example), the generic horizontal section of the rudder blade and main piece are to be examined according to [4.2.1].

5 Composite rudder scantlings

5.1 General

5.1.1 As a rule, the scantling of rudder in composite materials are to be checked according to:

- the forces and moments defined in [2]
- a ply by ply analysis of the composite elements of the rudder according to the methodology defined in NR467 Hull in composite materials
- safety coefficient as defined in the present Article.

5.2 Composite rudder stock

5.2.1 The rudder stock scantling is to be carried out according to the following stages, or by equivalent approach:

Note 1: Calculations defined in this requirement are applicable for the analysis of rudder stock made with an hollow square section as defined in Fig 4. For other shape of rudder stock (circular section for example), examination is to be based on a case by case basis.

a) General calculation consideration:

The scantling calculation is carried out according the following assumption (see Fig 4):

- The side parts of the rudder stock are examined under bending and torque moment induced by the rudder blade and are considered as a sandwich beam made by two skin and a core with quasi-nul mechanical characteristics
- The web parts of the rudder stock are examined under horizontal shear force and torque moment.

b) Moment and shear force per meter width in side parts:

The bending moment per meter width M_X, in KNm/m, and the shear force per meter width N_{XY}, in KN/m, are to be calculated as follow:

$$M_X = \frac{M_B}{\ell_X}$$

$$N_{XY} = \frac{M_{TR}}{\ell_Y \ell_X} \cdot 10^3$$

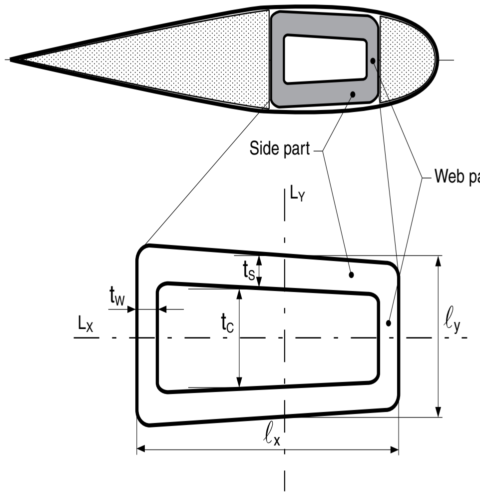
where:

M_B : Bending moment in the rudder stock, in N.m, calculated according to [2.3]

M_{TR} : Torque moment in the rudder stock, in N.m, calculated according to [2.2]

l_X and l_Y : Dimensions, in mm, of rudder stock section as shown on Fig 4.

Figure 4 : Typical section of composite rudder stock



c) Shear force per meter width in web parts:

The shear force per meter width N_{XY}, in KN/m, is to be calculated as follow:

$$N_{XY} = \left(\frac{Q}{2\ell_y} + \frac{M_{TR}}{\ell_x \ell_Y}\right) \cdot 10^3$$

where:

Q	:	shear force in rudder stock, in N, as defined in [2.3]
M_{TR}	:	Rudder torque, in N.m, as defined in [2.2]
l_X and l_Y	:	Dimensions, in mm, of rudder stock section as shown on Fig 4.

d) Rudder stock analysis:

The laminates behaviour of the side part and the web part of the rudder stock are to be analysed according to NR546 Hull in Composite Materials, Section 6. In each layers, actual stresses are to be calculated taking into account:

- For the side part of the rudder stock: Simultaneously the moment and shear force defined in b) (see also Note 2)
- For the web side of the rudder stock: The shear force defined in c).

Note 2: The transversal stresses induced by the moment in one side part, due to the contact pressure between this side part and the bearing, may be taken into account. In this case, these stresses in the side part in way of the bearing are to be calculated and combined according to NR546 Hull in Composite Materials, taking into account one side part as a beam, simply supported, having a length equal to ℓ_X and uniformly loaded by the contact pressure.

e) Scantling criteria of rudder stock:

In each layer of the rudder stock laminate (side and web parts), the safety coefficients SF defined in NR546 Hull in Composite Materials, Sec 6 [5], calculated for the maximum stresses and the combined stresses are to be greater than minimum rule safety coefficients defined in [5.2.2].

5.2.2 Safety coefficients

The safety coefficient SF_R to take into account for the rudder stock scantling are to be taken equal to:

$SF_R = 1{,}3\ SF_i$

where:

SF_i	:	Minimum rule safety coefficients SF (minimum stress criterion) and SF_{CS} (combined stress criterion), defined in Ch 6, Sec 3, [2.4.3] a).

5.3 Coupling for composite rudder

5.3.1 General case

a) As a general rule, the coupling for composite rudder is realized by direct gluing between the continuous rudder stock and the rudder blade.

The coupling is to be examined taking into account:

- The shear stress in the gluing joint between rudder stock and blade, and
- The shear stress in the rudder blade foam.

b) Shear stress in the gluing joint:

The shear stress τ_g, in N/mm², in the gluing joint is to be in accordance with the following formula:

- For cylindrical rudder stock:

$$\tau_g = \frac{2M_{TR}}{L_Z \pi D^2} 10^3 \le \frac{\tau_{Rg}}{SF_g}$$

where:

M_{TR} : Torque moment, in Nm, define in [2.2]

L_Z : Length, in mm, of rudder stock inserted in the rudder blade as shown on Fig 5

D : Mean diameter, in mm, of the part of the rudder stock inserted in the rudder blade

τ_{Rg} : Ultimate shear breaking stress, in N/mm², as defined in NR546 Hull in Composite materials, Sec 4 [5]

SF_g : Safety coefficient taken equal to 1,3 SF, where SF is defined in Ch 6, Sec 3, [2.4.3].

- For hollow square section stock:

$$\tau_g = \frac{M_{TR}}{L_X L_Y L_Z} 10^3 \le \frac{\tau_{Rg}}{SF_g}$$

where:

L_X, L_Y, L_Z: Dimension, in mm, of the rudder stock as shown on Fig 5

SF_g : Safety coefficient taken equal to 1,3 SF, where SF is defined in Ch 6, Sec 3, [2.4.3].

c) Shear stress in the rudder blade foam

The shear stress τ_f, in N/mm², in the rudder blade is to be taken to τ_g as defined in b) and is to fulfil the following formula:

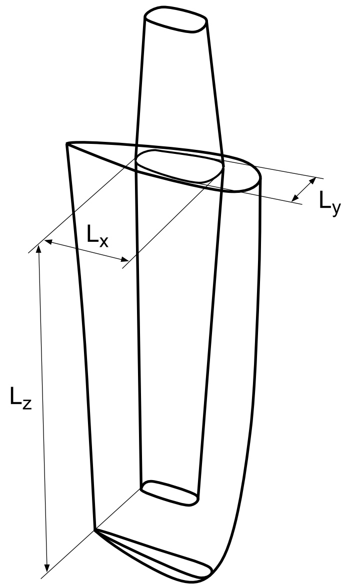
$$\tau_f \le \frac{\tau_{Rf}}{SF}$$

where:

τ_{Rf} : Ultimate breaking shear stress of the foam, in N/mm²

SF : Safety coefficient taken equal to 3,6.

Figure 5 : Composite rudder blade scantling



5.3.2 Coupling between metallic rudder stock and composite rudder blade

a) General:

As a rule, this type of coupling is realised by horizontal metallic arms fitted on composite rudder blade and connected to a metallic rudder stock.

Connection of arms with rudder blade and rudder stock is to be sufficient to ensure the transmission of the rudder torque defined in [2.2].

b) Scantling:

The scantling of the rudder arm is to be in accordance with the following requirements:

$$\sigma_{am} \ge \frac{M_{TR}}{nW_Z}$$

$$\tau_{Am} \ge \frac{C_R}{nA_{sh}}$$

where:

σ_{am} : Permissible stress, in N/mm², defined in [3.3.5]

τ_{Am} : Permissible stress, in N/mm², as defined in [3.3.5]

W_Z : Arms section modulus, in cm³, around Z axis as defined in Fig 1

A_{sh} : Minimum arms shear section in mm²

n : Number of arms connected to the rudder stock.

5.4 Composite rudder blade

5.4.1 General

As a rule, rudders made of composite materials are streamlined rudders. Skins constituting the rudder blade are made of single skin laminate separated by a core.

The rudder blade scantling is to be examined taking into account the loads defined in [2.2] and [2.3] and the following consideration:

- Face skins of the rudder blade submitted to tensile/compression stress under rudder torque moment (see [5.4.2])
- Core of the rudder submitted to shear force under rudder torque moment (see [5.4.2])
- Connection between face skin of the rudder blade and the rudder stock under rudder torque moment (see [5.3]).

The scantling of the generic horizontal sections of the rudder blade, checked taking into account the bending moments defined in [2.3], are to be in accordance with the safety coefficient SF_{RB} at least equal to the following value:

$SF_{RB} = 1{,}3\ SF_i$

where:

SF_i : Minimum rule safety coefficients SF (minimum stress criterion) and SF_{CS} (combined stress criterion), defined in Ch 6, Sec 3, [2.4.3] a).

5.4.2 Rudder blade scantling

As a rule, the rudder blade is to be considered as a sandwich panel, similar to the rudder blade scantling in way of the aft part of the web part as defined in Fig 4, and loaded as follow:

- Bending moment by width meter, in KNm/m:

$$M_Y = \frac{M_{TR}}{L_Z} \cdot 10^{-3}$$

- Shear force by width meter, in KN/m:

$$T = \frac{M_{TR}}{L_Z r} \cdot 10^{-3}$$

where:

M_{TR} : Rudder torque, in N.m, as defined in [2.2]

L_Z : Mean height, in m, of the rudder to be taken equal to the length of rudder blade in way of the rudder stock (see Fig 5)

r : Torque lever arm, in m, considered for the calculation of the rudder torque as defined in [2.2].

5.5 Composite rudder horn and solepiece

5.5.1 General

Rudder horn and solepiece made in composite are to be examined by direct calculation according to:

- Force, bending and torsional moments defined in [3.8]
- Stress analysis as defined NR546 Hull in Composite Materials.

The scantling of the sections of the rudder horn and solepiece are to be in accordance with the safety coefficient defined in Ch 6, Sec 3, [2.4.3] a) increased by a coefficient taken at least equal to:

- for main stress safety factor: 1,9
- for combined stress safety factor: 1,3

Section 3 Windows, Sidescuttles, Bulwark and Guard Rail

1 Sidescuttles and windows glasses

1.1 General

1.1.1 Application

The requirements of this Section apply to sidescuttles and windows exposed to the action of sea, green sea and weather.

Arrangements of sidescuttles and windows are to be in accordance with Ch 2, Sec 2, [3.5].

1.1.2 Definitions

Watertight means capable of preventing the passage of water through the structure in any direction with a proper margin of resistance under the sea pressure defined in Ch 4, Sec 3 and Ch 4, Sec 4.

Weathertight means capable of preventing the passage of water in any sea conditions in respect with the navigation notation.

A deadlight is a secured cover fitted to the inside of window and sidescuttle provided in the event of breakage of the window or the sidescuttle.

A storm cover is a secured cover fitted to the outside of window and sidescuttle, where accessible, provided in the event of breakage of the window or the sidescuttle.

1.2 National and International regulation

1.2.1 The requirements and arrangement of the present Section within the scope of classification and/or certification may be different from requirements of National Rules or International Convention (in particular ICLL 66). The Interested Party have to ensure compliance with any requirements issued by Flag Administration.

As an example, following item are to be checked with Flag Administration:

- Location of opening and/or non opening type of windows and sidescuttles
- Requirements about the number of deadlights or storm covers, their location and fittings
- Windows and sidescuttle materials, in particular in case where glass material is not used
- Windows location under the freeboard deck[(m)] (as defined in Ch 2, Sec 2, [2.2.1])
- Means and type of closing devices
- General scantling.

1.3 Materials

1.3.1 Sidescuttles and windows together their deadlights and storm covers, if fitted, are to be examined from a structure point of view, according to the present Section.

When a product certificate of windows and sidescuttles is not required, mechanical test results of window material (glass, plastic,...) are to be supplied and watertihgtness of window and sidescuttles is to be tested after fitted on board by hose test.

Note 1: As a rule, the minimum pressure in the hose to verify the tightness of the windows and sidescuttles fitted on board is to be at least equal to $2{,}0.10^5$ Pa. The nozzle diameter is to be not less than 12 mm and is to be applied at a maximum distance equal to 1,5 m.

1.4 Scantling

1.4.1 General

The design loads to take into account for the windows and sidescuttles glasses scantling are the local loads of the adjacent structure, as defined in Ch 4, Sec 3, [2.1] (wave loads), Ch 4, Sec 3, [3.1], if applicable (side shell impacts) and Ch 4, Sec 4, [5] (superstructure pressure).

As a general rule, the pressure are to be calculated at mid-height of the window or the side scuttle.

Window scantling defined in the present section are provided for the following edge condition:

- simply supported conditions (general case): When the edge of the window can rotate under the effect of lateral pressure
- clamped conditions: When the edge of the window can not rotate under the effect of lateral pressure (large windows supported by intermediate stiffeners for example).

1.4.2 Means of closing and deadlight or storm cover

The strength of closing devices, deadlights and/or storm covers are to be equivalent to the strength of the surrounding structure.

1.4.3 Thickness of monolithic window and sidescuttle glasses

The thickness of windows and sidescuttles glasses are based on the guaranteed minimum flexural strength R_m, in MPa, of the glass material used. For guidance only, the guaranteed minimum flexural strength R_m for glass window may be taken equal to:

- for glass thermally or chemically toughened glass: $R_m = 160$ N/mm²
- for PMMA glass: $R_m = 100$ N/mm²
- for polycarbonate: $R_m = 90$ N/mm²

Note 1: As a rule, the value of R_m is to be defined by the window supplier.

The thickness t, in mm, of windows and sidescuttles glasses is to be not less than the following values taking into account:

s : Shorter side, in m, of rectangular window or sidescuttle

ℓ : Longer side, in m, of rectangular window or side scuttle

d : Diameter, in m, of circular window or sidescuttle

Note 2: For windows and sidescuttles having other shapes, s and ℓ are to be determined by equivalent dimensions s_{eq} and ℓ_{eq} as defined in Tab 3.

a) Windows and side scuttles submitted to uniform pressure:

- Rectangular window or sidescuttle:

$$t = 31{,}6 s \alpha_{ec} \sqrt{\frac{\beta p}{R_m / S_f}}$$

where:

S_f : Safety factor equal to:
- for glass window: $S_f = 4{,}0$
- for plastic window: $S_f = 3{,}5$

β : Aspect ratio coefficient of the rectangular window or sidescuttle, obtained in Tab 1

α_{ec} : Coefficient to be taken equal to 1 for edges of glass considered as simply supported and 0,81 for edge of glass considered as clamped.

p :
- when located on the side shell:
  as defined in Ch 4, Sec 3, [2.1.2] with φ_2 taken equal to 1 for the calculation of p_{dmin}
- elsewhere:
  as defined in Ch 4, Sec 4, [5]

- Circular window or sidescuttle:

$$t = 16{,}7 d \alpha_{ec} \sqrt{\frac{p}{R_m / S_f}}$$

b) Windows and side scuttles submitted to side shell impact:

The thicknesses, in mm, of monolithic window and sidescuttles glasses are defined in Tab 2 where:

s, ℓ, d, R_m : As defined in a)

S_f : Safety factor equal to:
- for glass window: $S_f = 3{,}7$
- for plastic window: $S_f = 3{,}2$

μ : Aspect ratio coefficient of the elementary window or sidescuttle glass, equal to:

$$\mu = 1{,}21 \sqrt{1 + 0{,}33 \left(\frac{s}{\ell}\right)^2} - 0{,}69 \frac{s}{\ell} \le 1$$

Table 1 : Coefficient β

ℓ/s	β
1	0,284
1,5	0,475
2	0,608
2,5	0,684
3	0,716
3,5	0,734
≥ 4	0,750

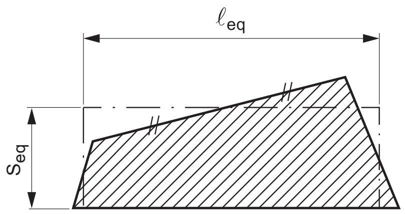
Table 2 : Thickness of monolithic window: Side shell impact

Type of edge condition	Circular window or sidescuttle		Rectangular window or sidescuttle	
Supported condition	if d ≤ 0,6 m **(1)**	$t = 16,7d\sqrt{\frac{p}{R_m/S_f}}$	if s ≤ 0,6 m **(2)**	$t = 21.2\sqrt{\frac{1}{\ell_b}}\mu s\sqrt{\frac{p}{R_m/S_f}}$
	if d > 0,6 m **(2)**	$t = 11,6\sqrt{\frac{1,5d^2-0,18}{\ell_b d}}\sqrt{\frac{p}{R_m/S_f}}$	if s > 0,6 m **(2)**	$t = 16,4\sqrt{2s-0,6}\sqrt{\frac{1}{\ell_b}}\mu\sqrt{\frac{p}{R_m/S_f}}$
Clamped condition	if d ≤ 0,6 m **(1)**	$t = 13,5d\sqrt{\frac{p}{R_m/S_f}}$	if s ≤ 0,6 m **(2)**	$t = 17,3\sqrt{\frac{1}{\ell_b}}\mu s\sqrt{\frac{p}{R_m/S_f}}$
	if d > 0,6 m **(2)**	$t = 9,5\sqrt{\frac{1,5d^2-0,18}{\ell_b d}}\sqrt{\frac{p}{R_m/S_f}}$	if s > 0,6 m **(2)**	$t = 13,4\sqrt{\frac{1,5s^2-0,18}{\ell_b s}}\mu\sqrt{\frac{p}{R_m/S_f}}$

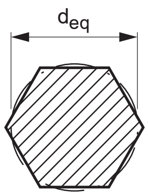
(1) $p = p_{ssmin}$ as defined in Ch 4, Sec 3, [3.1]
(2) $p = C_p P_{ssmin}$
ℓ_b : Length, in m, equal to: $\ell_b = 0,6\ (1 + s) \leq \ell$ or d
p_{ssmin} : Impact pressure, in kN/m², as defined in and Ch 4, Sec 3, [3.1]
C_p : Pressure coefficient equal to: $C_p = -0,98s^2 + 0,3s + 0,95 \geq 0,8$

Table 3 : Equivalent dimensions for windows

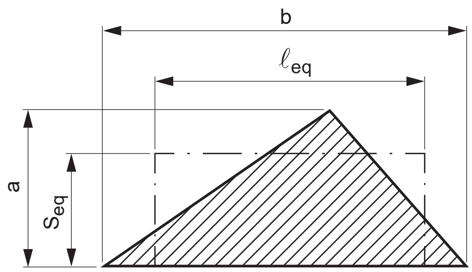
a) Quadrangle:
The equivalent rectangle has the same area



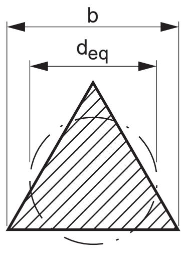
b) Polygon
The equivalent circle has the same area



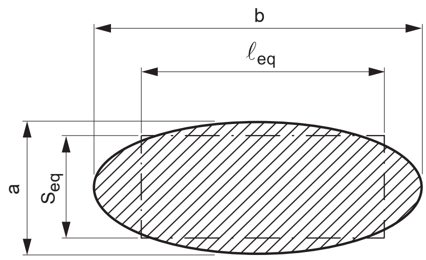
c) Triangle
$s_{eq} = 2a/3$
$l_{eq} = 3b/4$



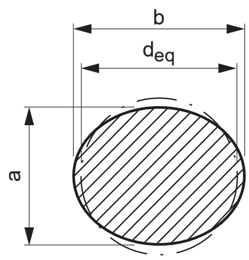
d) Equilateral triangle
$d_{eq} = 3b/4$



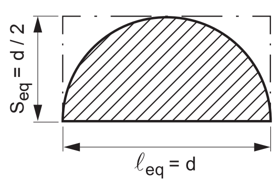
e) Flat ellipse
$s_{eq} = 0,87a$
$l_{eq} = 0,87b$



f) Round ellipse
$d_{eq} = \sqrt{ab}$



g) Semi circle
$s_{eq} = d/2$
$l_{eq} = d$



1.4.4 Thickness of laminated window with collaborating plies

Laminated windows with collaborating plies are glass windows realized with a layer of resin (polyvinyle butyral as a general rule) located between sheets of glass.

The equivalent thickness t_{eq}, in mm, of laminates made of two collaborating plies of the same material, and of thicknesses t_1 and t_2 separated by an interlayer of thickness t_I is to comply with the following formula:

$t_{eq} \geq t$

where:

t : Thickness, in mm, as defined in [1.4.3]

t_{eq} : $t_{eq} = \min[t_{1eq,s}, t_{2eq,s}]$

$t_{1eq,s}$, $t_{2eq,s}$: Equivalent thickness for strength as obtained from the following formulae:

$$t_{1eq,s} = \sqrt{\frac{t_{eq,d}^3}{t_1 + 2\Gamma t_{s2}}}$$

$$t_{2eq,s} = \sqrt{\frac{t_{eq,d}^3}{t_2 + 2\Gamma t_{s1}}}$$

$t_{eq,d}$: Equivalent thickness for deflection as obtained from the following formula:

$$t_{1eq,d} = \sqrt[3]{t_1^3 + t_2^3 + 12\Gamma I_S}$$

Γ : Shear transfer coefficient as obtained from the following formula, without being taken less than 0 (independent plies behaviour) and more than 1,0 (monolithic behaviour):

$$\Gamma = \frac{1}{1 + 9,6\frac{E}{G}\frac{I_S}{hs^2}\frac{t_I}{s^2}}$$

$$t_{s1} = \frac{hs \cdot t_1}{t_1 + t_2}$$

$$t_{s2} = \frac{hs \cdot t_2}{t_1 + t_2}$$

$$I_S = t_1 t_{s2}^2 + t_2 t_{s1}^2$$

$$hs = 0,5(t_1 + t_2) + t_I$$

G : Shear modulus of the interlayer at 25 °C, in N/mm², generally taken equal to 1,6 N/mm² for polyvinyl butyral (PVB). For other interlayer materials the shear modulus value at 25 °C for short time duration load (60 s) shall be declared by the interlayer material manufacturer

E : Young's modulus of the plies, in N/mm²

s : Shorter side, in m, of rectangular window or sidescuttle.

In case of multiple (more than two plies) laminates the calculation is to be iterated. The iteration is to start from the outer ply (the one directly loaded by water pressure) and end with the inner ply.

1.4.5 Thickness of laminated window with independent plies

The equivalent thickness t_{eq}, in mm, of laminates made of n plies of different thicknesses $t_{p,1}$, $t_{p,2}$, ..., $t_{p,n}$ is to comply with the following formula:

$$t_{eq} \geq t$$

where:

t : Thickness, in mm, of a monolithic window, calculated according to [1.4.3] for the same material than the ply giving the minimum value of $t_{eq,j}$.

t_{eq} : $t_{eq} = \min[t_{eq,j}]$

$$t_{eq,j} = \sqrt{\frac{\sum_{j=1}^{n} t_{p,j}^3}{t_{p,j}}}$$

j : Ply index, ranging from 1 to n

1.4.6 Thickness of double-glazed windows

Double glasses are glasses realized by two sheets of glass, separated by a spacebar hermetically sealed.

The thickness of the outside glass exposed to the loads of the double-glazed window is to be at least equal to the value defined in [1.4.3].

2 Bulwark and bulwark top rail

2.1 Application

2.1.1 The present requirements are applicable to bulwark built in glass or other materials located on exposed decks within the scope of protection of crew and passenger (falling overboard protection) and to bulwark top rail.

The scantling requirements for bulwarks located in prolongation of the side shell are defined in Ch 5, Sec 5.

2.1.2 Where bulwarks on weather deck form wells, freeing ports are to be provided as defined in Ch 2, Sec 2, [4].

2.1.3 The attention of the Interested Party is drawn on the fact that the height, the arrangement and the location on the ship of the bulwark and guard rail are to be in accordance with the flag Administration and are not covered by the present Rules.

2.2 Design loads

2.2.1 The loads to be considered independently are:

a) sea pressure: as defined in Ch 4, Sec 4, [5.3] for superstructure walls

b) falling overboard protection: The loads to be considered is an horizontal linear load to be applied to the bulwark top rail and to be taken not less than:
   - 1,0 kN/m if the bulwark is located in public space
   - 0,6 kN/m in other cases.

2.3 Glass bulwark scantling

2.3.1 The thickness of monolithic glass bulwark is to be not less than the following valus:

a) Glass bulwark supported in its 4 edges: The thickness is to be in accordance with the requirements defined in [1.4] taking into account the sea pressure defined in [2.2.1]a).

b) Glass bulwark supported in 2 opposite edges: The thickness is to be in accordance with the requirements defined in [1.4] taking into account a coefficient beta equal to 0,75 and loads defined in [2.2.1]a).

c) Glass bulwark clamped in its lower edge The thickness, in mm, is to be not less than:

$$t = 54,8H\sqrt{\frac{p}{R_m / SF}}$$

where:

H : Height, in m, of the bulwark

p : Sea pressure load as defined in [2.2.1]a)

R_m, SF : As defined in [1.4.3]

d) Other case: The scantling of glass bulwark supported in 3 edges or by clamps are to be considered on the basis of calculations submitted by the Designer.

Requirement defined in [1.4.6] may be considered for laminated glass.

2.3.2 Bulwark guard rail

Bulwark top rail scantling is to be checked by direct calculation taking into account the horizontal linear load defined in [2.2.1]b) and the following hypothesis:

- The bulwark top rail is considered as simply supported in way of stanchions
- The permissible stress is to be taken equal to 0,6 Ry, where Ry is defined in Ch 5, Sec 1.

When the bulwark top rail is embedded within the glass bulwark or when there is no bulwark top rail, the scantling of the glass bulwark is to be considered on the basis of calculations submitted by the Designer taking into account loads defined in [2.2.1]b) applied to the upper edge of the glass bulwark and safety coefficients defined in [1.4.3].

As a rule, the horizontal deflection of the glass bulwark top edge is not to be greater than L/100, where L is the span of the bulwark top edge between bulwark stays

2.3.3 Bulwark stanchion scantling

Bulwark stanchion scantling is to be checked according to Ch 5, Sec 2, [9.6.2]b) and by direct calculation within the scope of falling overboard protection.

2.3.4 Certification of glass bulwark

As a general rules, the glass is to be of toughened glass type.

As a rule, glass bulwark are to be certified under pendulum impact test according to National or International Standard.

2.4 Scantling of bulwark made with other materials

2.4.1 Bulwark made with other materials are to be examined on a case by case basis, taking into accounts loads defined in [2.2.1].

Section 4 Propeller Shaft Brackets

Symbols

N : Number of revolution per minute of the propeller

P_P : Power transmitted to the propeller, in kW

P : Mass of a propeller blade, in t

Note 1: If this value is unknown, P may be taken equal to: $P = P_{PROP} / (n+1)$

where:

P_{PROP} : Total mass of the propeller (hub included), in t

n : Number of propeller blades

R_P : Distance, in m, of the centre of gravity of a blade in relation to the rotation axis of the propeller

Note 2: If this value is unknown, R_P may be taken equal to: $R_P = D / 3$

where:

D : Diameter of the propeller, in m

L, ℓ : Lengths of shaft line, in m, defined in Fig 1

d_1 : Length, in m, of the arms as defined in Fig 1

d_2 : Distance, in m, between the shaft axis and the arm connection to the hull as defined in Fig 1

w_A : Section modulus, in cm^3, of the arms at the level of the connection to the hull with respect to a transversal axis

w_B : Section modulus, in cm^3, of the arms at the level of the connection to the hull with respect to a longitudinal axis

A : Sectional area, in cm^2, of the arms

A_S : Transversal shear sectional area, in cm^2, of the arms

F_C : Centrifugal force, in KN, as defined in [2.1.1]

σ_{ALL}, $\sigma_{ALL,S}$: Permissible stress, in N/mm^2, as defined in [1.1.3].

1 General

1.1 Propeller shaft bracket scantling

1.1.1 General arrangement

The two following propeller shaft bracket arrangements are considered in the present section:

- Double arm shaft bracket:

  This type of propeller shaft bracket consists in two arms arranged, as far as practicable, at right angles and converging in the propeller shaft bossing.

  Exceptions to this arrangement will be considered by the Society on a case by case basis.

- Single arm shaft bracket:

  This type of propeller shaft bracket consists of one arm. As a rule, this type of arrangement may be used only on yachts less than 65 m in length.

1.1.2 Scantling methods

Two different calculation methods are considered to check the shaft brackets according to the type of yacht:

- The calculation of the working rate in the shaft brackets takes into account an “unbalance” caused by the loss of one propeller blade. This unbalance causes a centrifugal force which is compare to a centrifugal force of the missing blade F_C (see [2])
- A second method may be used instead of the calculation here before if the moments in each arm of the shaft bracket M, as defined in [2]are less than 15 kN.m.

  This alternative method defined in [3] takes into account a moment caused by friction between the shaft propeller and the shaft brackets, caused by unexpected seizing.

Direct calculation by beam 3D model may also be carried out as an alternative, taking into account forces and moments defined in the present section.

1.1.3 Permissible stresses for steel and aluminium shaft bracket

The permissible stresses σ_{ALL} (for loss of blade method) and $\sigma_{ALL,S}$ (for alternative calculation seizing method) are to be as follow:

- For steel shaft bracket or equivalent:

$$\sigma_{ALL} = 0,30 R_{eH} \lambda$$

$$\sigma_{ALL,S} = 0,60 R_{eH} \lambda$$

where:

R_{eH} : Minimum guaranteed yield stress as defined in Ch 5, Sec 1, [3.1.3]

λ : Coefficient corrosion to be taken equal to:

- 1 for steel
- 1,1 for stainless steel

Note 1: R_{eH} is to be replaced by $0,42(R_{eH}+R_m)$ if $R_m < 1,4R_{eH}$, where R_m is the minimum guaranteed tensile strength.

- For aluminium shaft bracket:

$$\sigma_{ALL} = 0,35R_y$$

$$\sigma_{ALL,S} = 0,7R_y$$

where:

R_y : Minimum guaranteed yield stress after welding as defined in Ch 5, Sec 1, [4.1.2].

A higher permissible stress may be considered by the Society in case by case, according to the type of yacht, its motorization (two independent shaft lines, sailing yacht...).

1.1.4 Permissible safety coefficient for composite shaft bracket

Shaft brackets in composite materials are to be examined taking into account the:

- forces and moments defined in [2] and [3]
- the ply by ply stresses calculated according to NR546 Hull in Composite Materials.

The safety coefficients are to be at least equal to the following values:

- For the maximum stress criteria in each layer:

  $SF = 1,8\ C_V\ C_F\ C_R$
- For the combined stress in each layer:

  $SF = 1,5\ C_{CS}\ C_V\ C_F$

  where:

  C_V, C_F,C_R,C_{CS},:Partial safety factors defined in Ch 6, Sec 3, [2.4.2] and Ch 6, Sec 3, [2.4.3].

1.2 Shaft bossing and arm connection to hull structure

1.2.1 Scantling of propeller shaft bossing

The length of the propeller shaft bossing is to be not less than the length of the aft sterntube bearing bushes (see Pt C, Ch 1, Sec 2, [4.3.4]).

As a rule, the thickness of the propeller shaft bossing is to be not less than 0,33 d_P, where d_P is the propeller shaft diameter, in mm, measured inside the liner, if any.

1.2.2 Arm connection to hull structure

As a rule, in way of bracket arms attachments, the thickness of deep floors or girders is to be suitably increased. Moreover, the shell plating is to be increased in thickness and suitably stiffened.

The securing of the arms to the hull structure is to prevent any displacement of the brackets with respect to the hull.

The connection of the arm with bottom structure is to withstand bending moment and forces defined in the present section.

2 Loss of a blade

2.1 General

2.1.1 Centrifugal force

The centrifugal force F_C, in KN, due to the loss of blade is defined by the following formula:

$$F_C = \left(\frac{2\pi 0.8N}{60}\right)^2 R_P P$$

2.2 Double arm propeller shaft brackets

2.2.1 Scantling of arms

The moment in the arm, in kN.m, is to be obtained from the following formula:

$$M = \frac{F_C}{\sin\alpha}\left(\frac{L}{\ell}d_1\cos\beta + L - \ell\right)$$

where:

α : Angle between the two arms

β : Angle defined in Fig 1

The stresses, in N/mm², in bending σ_F, in compression σ_N and in shear τ are to be in compliance with the following formula:

$$\sqrt{(\sigma_F + \sigma_N)^2 + 3\tau^2} \le \sigma_{ALL}$$

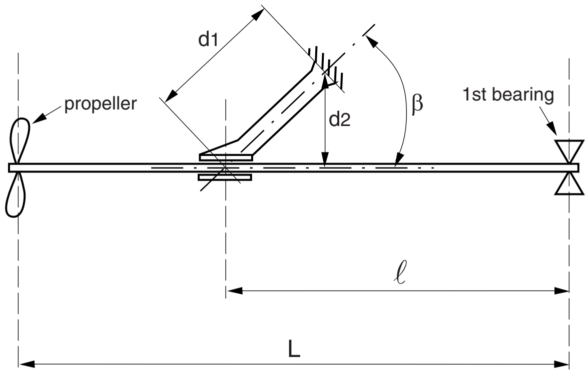
where:

$$\sigma_F = \frac{M}{w_A}10^3$$

$$\sigma_N = 10F_C\frac{L\sin\beta}{A\ell\sin\alpha}$$

$$\tau = 10F_C\frac{L\cos\beta}{A_S\ell\sin\alpha}$$

Figure 1 : Arm dimensions



2.3 Single arm propeller shaft brackets

2.3.1 Scantling of arm

The moment in case of a single arm, in kN.m, is to be obtained from the following formula:

$$M = 0,75F_C\frac{L}{\ell}d_2$$

The stresses, in KN/mm², in bending σ_F and in shear τ are to be in compliance with the following formula:

$$\sqrt{\sigma_F^2 + 3\tau^2} \le \sigma_{ALL}$$

where:

$$\sigma_F = \frac{M}{w_B}10^3$$

$$\tau = 10F_C\frac{L}{A_S\ell}$$

3 Alternative calculation seizing

3.1 General

3.1.1 Application

As indicated in [1.1.2], this alternative method is applicable if the bending moments M in arms as defined in [2.2.1] or in [2.3.1] are less than 15 kN.m.

3.1.2 The propeller torque M_P, in kN.m, transmitted to the shaft bracket is to be obtained from the following formula:

$$M_P = \frac{60P_P}{2\pi N}$$

Note 1: The angle β defined in Fig 1 is neglected if it is not less than 80°. If this condition is not respected, direct calculation will have to be made on a case by case.

3.2 Double arm propeller shaft brackets

3.2.1 Scantling of arms

The moment in each arm, in kN.m, at the attachment with the shaft propeller is to be obtained from the following formulae:

$$M_1 = \frac{M_P}{1 + \frac{E_2 I_2 d'_1}{E_1 I_1 d'_2}}$$

$$M_2 = \frac{M_P}{1 + \frac{E_1 I_1 d'_2}{E_2 I_2 d'_1}}$$

where:

E_1, E_2 : Young's modulus of each arm, in N/mm^2

I_1, I_2 : Inertia of each arm, in cm^4, with respect to a longitudinal axis

d'_1, d'_2 : Lengths of each arm (as defined by d_1 in Fig 1.

The stresses in each arms, in N/mm^2, in bending σ_F, in compression σ_N and in shear stresses τ are to be in compliance with the following formula:

$$\sqrt{(\sigma_{Fi} + \sigma_{Ni})^2 + 3\tau_i^2} \le \sigma_{ALL,S}$$

where, for each arm:

$$\sigma_{F1} = \frac{M_1}{w_{B,1}} 10^3$$

$$\sigma_{F2} = \frac{M_2}{w_{B,2}} 10^3$$

$$\sigma_{N1} = 10 . \frac{3}{2 A_1 \sin\alpha} \left(\frac{M_2}{d_2} + \frac{M_1}{d_1} \cos\alpha \right)$$

$$\sigma_{N2} = 10 . \frac{3}{2 A_2 \sin\alpha} \left(\frac{M_1}{d_1} + \frac{M_2}{d_2} \cos\alpha \right)$$

$$\tau_1 = 10 \frac{3 M_1}{2 d_1 A_{S,1}}$$

$$\tau_2 = 10 \frac{3 M_2}{2 d_2 A_{S,2}}$$

where:

$w_{B,1}$, $w_{B,2}$: Section modulus, in cm^3, of each arm at the level of the connection to the hull with respect to a longitudinal axis

A_1, A_2 : Sectional area, in cm^2, of each arm

$A_{S,1}$, $A_{S,2}$: Shear sectional area, in cm^2, of each arm.

3.3 Single arm propeller shaft brackets

3.3.1 Scantling of arm

The moment in case of a single arm, in kN.m, is to be obtained from the following formula:

$$M = M_p$$

where:

The bending stress σ_F, in N/mm^2, is to be in compliance with the following formula:

$$\sigma_F \le \sigma_{ALL,S}$$

where:

$$\sigma_F = \frac{M}{w_B} 10^3$$

Section 5 Independent Tanks

1 Independent tanks scantling

1.1 Application

1.1.1 The present Section deals with scantlings of independent tanks, in steel, aluminium alloys, composites, plywood or HDPE materials.

1.2 Local scantling

1.2.1 The scantling of plates, ordinary and primary stiffeners are to be examined as defined in:

- For steel and aluminium structure:

  Ch 5, Sec 5
- For composite, plywood and HDPE structure:

  Ch 6, Sec 5.

The pressures to take into account in tanks are defined in Ch 4, Sec 4, [2] and Ch 4, Sec 4, [3].

2 Independent tank fitting in board

2.1 General

2.1.1 The connection of independent tanks to hull structure is to be examined by direct calculation.

These connections to hull structures and the local tank structure reinforcements are to be able to withstand the reactions induced by the full tank weight, taking into account yacht motion and accelerations.

2.1.2 Full tank loads

The loads induced by the independent tank to the hull connections may be considered as a force applied at the center of gravity of the tank, oriented according heel and trim defined in a), and of an intensity equal to the total weight of the full tank combined with accelerations given in b).

a) The yacht motions to take into account are as follow:
   - Transversal heel: Depending of yacht type:
     - 30° for monohull sailing yacht,
     - 20° for monohull motor yacht, and
     - 10° for all types of multihull.
   - Longitudinal trim: 10° for all type of yacht.

b) The yacht accelerations, expressed in g, to combine with yacht motion are as follow:
   - Vertical acceleration a_z:
     - according Ch 4, Sec 3, [4.1.4] for planing hull motor yacht without being less than 1,25
     - according Ch 4, Sec 3, [4.2.4] for monohull sailing yacht, without being less than 1,25
     - 1,25 for the other types of yacht.
   - Transversal acceleration:
     - 1,2 for all types of yacht.
   - Longitudinal acceleration:
     - 1,1 for all types of yacht.

2.1.3 Scantling criteria

The permissible stresses and/or the safety coefficients to take into account for the examination of connections and for local reinforcements in tank and hull structure are defined in Ch 5, Sec 3 for steel and aluminium structure and in Ch 6, Sec 3 for composite, plywood and HDPE structure.

Section 6 Local Hull Structure Reinforcements for Standing and Running Rigging

1 General

1.1 Application

1.1.1 Definitions

In the present section, the:

- Standing rigging includes all the fixed components which support the masts on a sailing yacht
- Running rigging includes all the components used to operate the sails for raising/lowering, controlling...

1.1.2 The present Section defines the structural requirements for the scantling of chainplates and their connection to the hull structure, as well as the local hull structure reinforcements.

1.1.3 The running rigging components and their connection to the hull structure are not covered by the classification and are the responsibility of the designer.

The maximum forces induced by the running rigging in way of the components (winches, padeyes, sheaves and T-track) are to be submitted for information.

1.1.4 When the rigging is classed within the scope of assignment of additional class notations **WPS1** or **WPS2** according to NR206 Classification of Wind Propulsion Plants on Board Ships, the local hull structure reinforcement are to be in accordance with NR206, Sec8.

2 Chainplates and local hull structure scantling

2.1 Design Loads

2.1.1 General

Loads induced by the standing rigging (stays, backstays and vertical/lower shrouds) are to be submitted by the designer or the yard.

These loads can be:

a) The actual design loads defined by the designer for the various sailing conditions taking into account the different sail configurations for all wind heading, including gust effects, from head wind to down wind, and sail reductions and inertia loads induced by ship motions due to sea states.

The actual design loads may be also determined on the basis of the maximum ship moment of heel.

b) The breaking load of the stays and the shrouds when the design loads defined in a) are not submitted,.

Note 1: For shrouds made in aramid or carbon material, the design loads defined by the method a) is recommended.

2.1.2 Design loads

As a general rule, the loads F_S in N, to take into account for the chain plate local hull structure scantling, are to be taken equal to:

$$F_S = F_D \cdot C_S$$

where:

F_D : Design load, in N, defined in [2.1.1] a) or b)

C_S : Safety coefficient taken equal to:

- if F_D is obtained as defined in [2.1.1] a): C_S= 1,3
- if F_D is obtained as defined in [2.1.1] b):

  Cs = 0,43 for steel wire shroud or stay

  Cs = 0,52 for steel rod shroud or stay

  Cs = 0,43 for carbone shroud or stay

  Cs = 0,33 for PBO shroud or stay

In case of several shrouds or stays connected to the same chainplate, the applied global load to take into account is to be equal to the sum of the F_S of the stronger shroud and of 0,8 times the F_S of the others.

2.2 Scantling criteria

2.2.1 Steel and aluminium alloy for chainplate and/or local hull structure reinforcement

The maximum permissible stresses for steel and aluminium chainplates and local hull structure reinforcement are to be taken equal to the minimum following values:

$$\sigma_{E,\,ALL} = \sqrt{\sigma_B^2 + 3\tau_T^2} \leq 0{,}68R_y$$

$$\tau_{ALL} \leq 0{,}40R_y$$

$$\sigma_p \leq R_y$$

where:

σ_B : Tensile stress, in N/mm²

τ_{ALL} : Shear stress, in N/mm²

σ_p : Eye pressure, in N/mm²

R_y : Minimum yield stress, in N/mm² as defined in Ch 5, Sec 1, [3.1.5] for steel and in Ch 5, Sec 1, [4.1.2] for aluminium alloys.

2.2.2 Composite materials for chainplate and/or hull structure

The safety coefficients SF_S are to be taken at least equal to 1,25 SF_i, where:

SF_i : Minimum rule safety coefficients, defined in Ch 6, Sec 3, [2.4], equal respectively to SF and SF_{CS} calculated with a partial safety factor C_i taken equal to 1.

2.3 Scantling of chainplates

2.3.1 Metallic chainplates

The tensile stress $\sigma_{tensile}$, in MPa, in the chainplate is to be taken equal to:

$$\sigma_{tensile} = F_S / A_t$$

where:

F_S : Load, in N, defined in [2.1.2]

A_t : Total cross section, in mm², solicited in tensile

The shear stress τ, in MPa, in the chainplate is to be taken equal to:

$$\tau = F_S / A_S$$

where:

F_S : Load, in N, defined in [2.1.2]

A_S : Total section, in mm², solicited in shear

The chainplate eye pressure $\sigma_{bearing}$, in MPa, is to be taken equal to:

$$\sigma_{bearing} = F_S / (D \cdot th_C)$$

F_S : Load, in N, defined in [2.1.2]

D : Diameter, in mm, of the chainplate eye

th_C : Thickness, in mm, of the chain plate in way of the eye.

2.3.2 Composite chainplates

The review of chainplates made of composite materials is to be performed on a case by case basis, taking into account:

- The loads defined in [2.1.2]
- The global stresses defined in [2.3.1]
- The layer by layer analysis as defined in NR546 Hull in composite Materials, Section 6.

2.4 Scantling of local hull structure in way of chainplates

2.4.1 Application

The main types of connection between chainplates and their supporting structures considered in this rules are welded, bolted, or bonded connections. Other type of connection are examined on a case by case basis by the Society.

All these type of connections are to be examined by direct calculations.

Loads taken into account for the scantling of local hull reinforcements are defined in [2.1.2].

2.4.2 Welded connections

Where welded connections of metallic chainplates to metallic hulls are used, they are to comply with all requirements relating to weldings, as defined in Ch 5, Sec 7.

The scantling of the weldings is to be carried out taking into account the allowable stresses defined in [2.2.1].

2.4.3 Bolted connection

Material and class of bolts are to be submitted.

The scantling of the bolts is to be carried out taking into account the allowable stresses defined in [2.2.1].

Where applicable, bolts may be pre-stressed in compliance with appropriate standards. In such a case, the class of bolts is to be selected accordingly and details of pre-stressing process are to be submitted.

Bolting system is to be so design as to allow taking off for inspection.

Where a backplate is provided, its thickness is to be at least equal to 0,25 times the bolt's diameter

Where there is no backplate, nut is to be fitted with a washer for each bolt.

Dimensions of washers cannot be taken smaller than the following:

- Diameter to be, at least, equal to 4 times the bolt's diameter
- Thickness to be, at least, equal to 0,25 times the bolt's diameter.

For metallic hulls, bolting system is to be protected from galvanic corrosion where materials of nuts and washers are made of different metallic materials.

Arrangement are to be provided to retain bolt tightening.

2.4.4 Bonded connection

The bonded connections are mainly defined by the shear surface of bonding capable of sustaining the applied loads.

Documentation and material data sheet of the type of adhesive used, surface treatment, curing process and geometry of bonded joint are to be submitted.

The bonding surface between chainplates and hull structure are to be sufficient to ensure a safety coefficient in shear stress in the adhesive joint at least equal to 0,6 SF, where SF is defined in Ch 6, Sec 3, [2.4.4].

Mechanical test may be requested by the Society in order to check that the bonded connection as produced by the Yard is, at least, equivalent to the theoretical properties. In this case, the sample tests are to be performed according to NR546 Hull in Composite Materials, and are to be representative of the bonded connection (adhesive type, type of components to bond, surface treatment, curing process...).

3 Forestay chainplate for catamaran

3.1 General

3.1.1 For catamaran, when the forestays are fitted on a cross beam connected to the fore part of the floats, the cross beam scantling is to be checked by a direct calculation based on the following hypothesis:

- the cross beam and its structural elements is to be calculated as a beam supported at each ends in way of the floats
- design loads as defined in [2.1]
- scantling criteria as defined in [2.2]

Note 1: The forestay chainplate, the cross beam and the chain plates between the fore beam and the hull are considered as "chain plates".

3.1.2 Additional requirement for the cross beam

As a general rule, in addition to [3.1.1], the cross beam is also to be checked under buckling due to the digging in wave loading as defined in Ch 4, Sec 2, [4].

The cross beam is to be examined as pillar, as defined in Ch 5, Sec 8, [2] for steel cross beam, in Ch 5, Sec 8, [3] for aluminium cross beam and in Ch 6, Sec 5, [6] for composite cross beam, taking into account a compression axial force F_A, in KN, equal to:

$F_A = F''/6$

where:

F'' : Horizontal Archimedian overpressure force induced by the digging in wave, defined in Ch 4, Sec 2, [4.2.1]

The maximum allowable axial loads are to be checked as defined in Ch 5, Sec 8, [2.1.3] a) (for steel), in Ch 5, Sec 8, [3.1.2] a) (for aluminium) and in Ch 6, Sec 3, [2.4.3] a) and b) for buckling (for composite).

As a rule, the present structure check is to be carried out independently from [3.1.1].

3.1.3 Other arrangement

When a longitudinal beam is provided between the cross beam and the fore part of the platform of the catamaran in way of the forestay chain plate, the buckling of the longitudinal beam is to be checked considering:

- a compression force equal to the horizontal component of the force induced by the forestay
- a buckling approach as defined in Ch 5, Sec 8, [2] (for steel beam), Ch 5, Sec 8, [3] (for aluminium beam) or in Ch 6, Sec 5, [6.1.1] (for composite beam).
- a maximum allowable axial loads as defined in Ch 5, Sec 8, [2.1.3] a) (for steel), Ch 5, Sec 8, [3.1.2] a) (for aluminium or Ch 6, Sec 5, [6.1.1] (for composite).

Section 7 Solid Keel for Sailing Yachts

Symbols

L_{WL} : Length at waterline, in m, as defined in Ch 1, Sec 2, [2.2.3]

X_K : Longitudinal distance, in m, between the aft perpendicular as defined in Ch 1, Sec 2, [2.3.2] and the center of gravity of the keel

P : Total weight of keel, in KN

a_H : Heave vertical acceleration, in g, as defined in Ch 4, Sec 3, [4.2.2].

a_{PFP} : Pitch vertical acceleration, in g, as defined in Ch 4, Sec 3, [4.2.3]

Z_{keel} : Distance, in m, between the external side of hull's bottom and the centre of gravity of the keel.

1 General

1.1 Application

1.1.1 The present Section defines structural requirements for the scantling of solid keels and local bottom hull reinforcement of sailing yachts. Where a bulb is provided, the connection between bulb and keel is also covered by the present section.

Note 1: Solid keel means keel provided to ensure the stability of the yacht.

1.1.2 Lifting retractable keels necessary for maintaining the yacht's stability are reviewed on a case-by-case basis taking into account design loads defined in the present Section.

1.1.3 Leeboard provided to prevent leeway on sailing yacht are not covered within the scope of classification. However, forces exerted by leeboard to the hull structure are to be submitted by the designer for the examination of the bottom hull structure.

1.1.4 Keel grounding is not covered by the classification and/or certification.

1.2 Materials

1.2.1 General

Protection against galvanic corrosion is to be provided between materials of keel, hull structure, bulb and bolts when materials such as steel, stainless steel, aluminium or composite (with carbon fiber for example) are used together.

1.2.2 Keels made of steel

All structural parts of keels are to be made of rolled steel, steel forging or steel casting according to applicable requirements of NR216 Materials and Welding.

Keels fabrication by welding is to be carried out in compliance with the applicable Society Rules and in particular in compliance with Chapter 12 of NR216 Materials and Welding.

1.2.3 Keels made of aluminium

Aluminium material used for structural parts of keels and welding are to comply with requirements of NR216 Materials and Welding and NR561 Hull in Aluminium Alloys.

The loss of mechanical properties of some aluminium alloys (6000 series) induced by welding operation is to be taken into account for scantling.

1.2.4 Keels made of composite

All composite parts of keels are to be examined according the approach defined in NR546 Hull in Composite Materials, taking into account the loads and safety coefficients defined in the present Section.

The Society can request that mechanical tests be carried out as defined in NR546 Hull in Composite Materials.

2 Design loads

2.1 Application

2.1.1 As a general Rule, design loading cases to apply on keels and supporting structures are those where sailing yacht is at a heel angle of 30° with respect to vertical and a trim angle of 10° with respect to horizontal, taking into account the accelerations defined in Ch 4, Sec 3, [4.2].

Hydrodynamic pressure on solid keel induced by leeway are not considered.

2.1.2 Solid keel with bulb

In addition to forces and bending moments generated by loading cases defined in [2.1.1], torsional moments (induced where the centre of gravity of the bulb, at lower end of keel, is significantly apart from the torsional axis of the keel) may be taken into account.

2.2 Loadings induced by roll

2.2.1 Loads

The design loads due to roll motion of yacht, in KN, are to be taken equal to:

$$F_{hheel} = P \cdot (1 + a_H) \cdot \sin 30$$

$$F_{vheel} = P \cdot (1 + a_H) \cdot \cos 30$$

where:

F_{hheel} : Horizontal component of the keel weight, in KN

F_{vheel} : Vertical component of the keel weight, in KN

2.2.2 Bending moment at bottom hull level

The bending moment M_{heel}, in kN.m, induced by keel due to roll motion of yacht at hull bottom is to be taken equal to:

$$M_{heel} = F_{hheel} \cdot Z_{keel}$$

2.2.3 Bending moment in horizontal keel sections

The bending moment in an horizontal section of the keel is to be calculated according to [2.2.2] taking into account a bending lever arm Z equal to the distance between the center of gravity of the keel and the horizontal section of the solid keel at the calculation point considered.

2.3 Loads induced by pitch

2.3.1 Loads

The design horizontal load F_{pitch} due to pitch motion of yacht, in KN, is to be taken equal to:

$$F_{pitch} = P\left[\sin 10(1 + a_H) + a_{PFP}\frac{Z_{keel}}{L_{WL} - X_K}\right]$$

2.3.2 Bending moment at bottom hull level

The bending moment M_{pitch} , in kN.m, induced by keel due to pitch motion of yacht is to be taken equal to:

$$M_{pitch} = F_{pitch} \cdot Z_{keel}$$

2.3.3 Bending moment in horizontal keel sections

The bending moment in an horizontal section of the keel is to be calculated according to [2.3.2] taking into account a bending lever arm Z equal to the distance between the center of gravity of the keel and the horizontal section of the solid keel at the calculation point considered.

3 Solid keel scantling

3.1 General

3.1.1 The bending moments defined in [2.2.3] and in [2.3.3] are be used for the scantling of the solid keel.

In each sections considered, the horizontal and vertical forces due to roll and pitch are to be taken equal to the values defined in [2.2.1] and [2.3.1].

Stresses or safety coefficient induced by bending and shear forces are to be in accordance with [6].

4 Hull bottom / keel connection

4.1 General

4.1.1 Forces and bending moments defined in [2.2] and in [2.3] are to be used for the scantling of the connection between solid keel and internal bottom hull structure.

4.2 Connection by welding

4.2.1 Stresses induced by bending and shear forces in the bottom hull structure and in the welding connections are to be determined by direct calculations and are to be in accordance with [6].

4.3 Connection by bolting arrangement

4.3.1 Bolting generalities

Bolt materials and class are to be specified and have to comply with the following requirements:

a) Bolts are to be of stainless steel or equivalent sea-corrosion resistant material. The back plate, washers, nuts... are to be made of the same materials or of a compatible material of the keel bolts

b) As a rule, a large back plate extending from one bolt to the symmetrical bolt is to be provided. The thickness of this back plate is not to be less than 0,25 times the bolt diameter

c) Washers are to be provided under the nut head of each keel bolt. The diameter of the washer is not to be less than 4 times the bolt diameter, and its thickness is not to be less than 0,25 times the bolt diameter

d) Bolting system is to be in such a way that taking off can be handled for inspection

e) Nuts of bolting system are to be so arranged as to allow inspection

f) Where applicable, bolts may be pre-stressed in compliance with appropriate standards. In such a case, the grade of bolts is to be selected accordingly and details of pre-stressing process are to be submitted.

4.3.2 Bolts scantling criteria

Permissible stresses to take into account for the scantling of bolts are defined in [6.3].

4.3.3 Scantling of vertical bolting system

The type of keel dealt in this requirement is the keel bolted to the hull bottom structure as shown on Fig 1.

The bolts are to be designed to sustain combined tensile and shear forces, induced by loads defined in [2], as follow:

- Tensile forces:

  For each bolt i, the total tensile stress σ_i, in MPa, can be estimated by the following formula (see Fig 1):

$$\sigma_i = \frac{M_{heel} X_i 10^2}{I_{X'X'}} + \frac{M_{pitch} Y_i 10^2}{I_{Y'Y'}} + \frac{F_{vheel} 10^3}{A_{SH}}$$

where:

M_{heel} : As defined in [2.2.2]

M_{pitch} : As defined in [2.3.2]

F_{vheel} : As defined in [2.2.1]

$I_{X'X'}$: Total inertia of all bolts, in cm^4, with respect to global axis X'X' as defined in Fig 1

$I_{Y'Y'}$: Total inertia of all bolts, in cm^4, with respect to global axis Y'Y' as defined in Fig 1

X_i : Distance, in mm, of the considered bolt i to the global axis X'X'

Y_i : Distance, in mm, of the considered bolt i to the global axis Y'Y'

A_{SH} : Total cross section, in mm^2, of all bolts

Note 1: X'X' axis is defined in Fig 1 where X', in m, is equal to $b_{i\,max}/2$, were $b_{i\,max}$ is equal to the greater value of the distances between bolts b_i.

Note 2: Y'Y' axis is defined as the neutral fibre of the global cross section of all the bolts in relation to the longitudinal axe of the solid keel (see Fig 1).

- Shear forces:

  For each bolt i, the shear stress τ_i, in MPa, can be estimated by the following formula:

$$\tau_i = \frac{(F_{hheel} + F_{pitch}) 10^3}{A_{SH}}$$

where:

F_{hheel} : As define in [2.2.1]

F_{pitch} : As define in [2.3.1]

A_{SH} : Total shear area section, in mm^2, of all bolts.

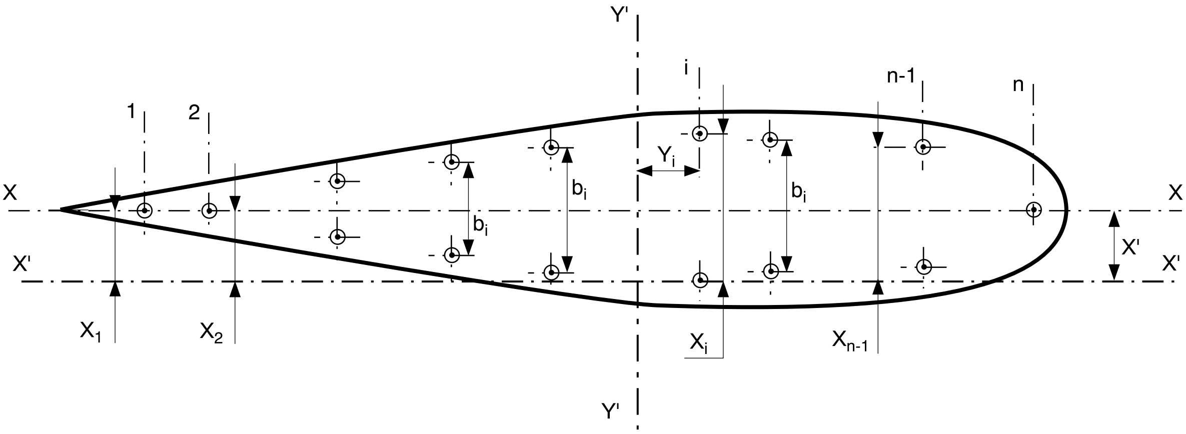
4.3.4 Horizontal bolting scantling

The type of keel dealt in this requirement is the type of keel crossing the bottom hull and directly bolted to primary longitudinal structure of the hull structure by horizontal bolts.

The bolts are to be designed to sustain tensile and shear forces, induced by loads defined in [2].

This type of bolting is to be examined on a case by case basis by the resolution of the bending moments M_{heel} and M_{pitch} in vertical forces to combined with vertical force F_{vheel}.

Figure 1 : Keel bolting arrangement



4.4 Connection for hull in composite materials

4.4.1 Stresses induced by bending and shear forces in the connections between solid keel and bottom hull structure are to be checked according NR546 Hull in Composite Materials, and in accordance with [6].

4.5 Movable keels

4.5.1 Attachments of movable keel operating systems to side and/or deck are to be designed in order that distributions of forces and moments, defined in [2], induce stresses within allowable stresses level defined in [6].

Forces induced by the operating systems are to be submitted by the designer.

5 Solid keel / bulb connection

5.1 General

5.1.1 When a bulb is provided, bolted connection between bulb and fin keel is to be examined according the method defined in [4.3].

Moment and forces to take into account are defined in [2.2] and [2.3] with the following hypothesis:

- The weight P, in t, to take into account is the weight of the bulb,
- The distance Z_{keel} to consider is the distance between the center of gravity of the bulb and the lower part of the fin keel.

6 Allowable stresses and safety coefficients

6.1 Steel and aluminium

6.1.1 Stresses in structure and welding (tensile, shear and Von Mises) are to be at least less than the local permissible stresses defined in Ch 5, Sec 3 for steel structure and aluminium alloy structure.

6.2 Composite materials

6.2.1 Composite structure analysis is to be carried out as defined in NR546 Hull in Composite Materials, taking into account bending moment and shear forces defined in [2]. Safety coefficient are to be as defined in Ch 6, Sec 3

6.3 Bolt

6.3.1 For each bolt, the Von Mises combined stress is to be less than 0,5 time R_{eH}, where R_{eH} is the minimum guaranteed yield strength of bolts, in MPa.

Note 1: When pre-stresses bolts are used, the permissible scantling criteria of bolts are individually examined on the basis of standard specially dedicated.

NR500

RULES FOR THE CLASSIFICATION AND THE CERTIFICATION OF YACHTS

Part C
Machinery, Electricity, Automation and Fire Protection

Part C
Machinery, Electricity, Automation and Fire Protection

CHAPTER 1
MACHINERY

Section 1 General Requirements and Application

1 General

1.1 Application

1.1.1 Part C, Chapter 1 applies to the design, construction, installation, tests and trials of main propulsion and essential auxiliary machinery systems and associated equipment, pressure vessels, piping systems, and steering and manoeuvring systems installed on board classed yachts, as indicated in each Section of this Chapter and as far as class is concerned only.

Where the word "yachts" is used in the subsequent Sections, it means yachts and charter yachts.

1.1.2 In the present Chapter, the length reference to 24 m applies to length L_{LL} as defined in Pt A, Ch 1, Sec 1, [3.2.2].

1.1.3 Charter yachts carrying more than 36 passengers are not covered by this Chapter and are to comply with applicable rules for ships granted with service notation **passenger ship**. Requirements specified in NR467 Rules for Steel ships Part C, Chapter 1 and NR467, Pt D, Ch 11, Sec 4 apply.

1.2 National regulations

1.2.1 When the Administration of the State whose flag the yacht is entitled to fly has issued specific rules covering machinery, the Society may accept such rules for classification purposes in lieu of those given in this Chapter.

In this case, it is the responsibility of the Interested Party to specify to the Society the condition of operation of the Yacht and the applicable specific Flag Rules.

In such cases, a special notation regarding the above is entered on the Certificate of Classification of the yacht.

1.3 Documentation to be submitted

1.3.1 Before the actual construction is commenced, the Manufacturer, Designer or yacht builder is to submit to the Society the documents (plans, diagrams, specifications and calculations) requested in the relevant Sections of this Chapter.

1.4 Definitions

1.4.1 Machinery spaces

Machinery spaces are machinery spaces of category A and other spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

1.4.2 Machinery spaces of category A

The definition of machinery spaces of category A is given in Ch 4, Sec 1, [3.4.15].

1.4.3 Fuel oil unit

Fuel oil unit is the equipment used for the preparation of fuel oil for delivery to an oil fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0,18 N/mm^2.

2 Design and construction

2.1 General

2.1.1 The machinery, pressure vessels, associated piping systems and fittings are to be of a design and construction adequate for the service for which they are intended and are to be so installed and protected as to reduce to a minimum any danger to persons on board, due regard being paid to moving parts, hot surfaces and other hazards.

The design is to have regard to materials used in construction, the purpose for which the equipment is intended, the working conditions to which it will be subjected and the environmental conditions on board.

2.2 Materials, welding and testing

2.2.1 General

Materials, welding and testing procedures are to be in accordance with the requirements of NR216 Materials and Welding and those given in the other Sections of this Chapter. In addition, for machinery components fabricated by welding the requirements given in [2.2.2] apply.

2.2.2 Welded machinery components

Welding processes and welders are to be approved by the Society in accordance with NR216 Materials and Welding, Chapter 12.

References to welding procedures adopted are to be clearly indicated on the plans submitted for approval.

Joints transmitting loads are to be either:

- full penetration butt-joints welded on both sides, except when an equivalent procedure is approved
- full penetration T- or cruciform joints.

For joints between plates having a difference in thickness greater than 3 mm, a taper having a length of not less than 4 times the difference in thickness is required. Depending on the type of stress to which the joint is subjected, a taper equal to three times the difference in thickness may be accepted.

T-joints on scalloped edges are not permitted.

Lap-joints and T-joints subjected to tensile stresses are to have a throat size of fillet welds equal to 0,7 times the thickness of the thinner plate on both sides.

In the case of welded structures including cast pieces, the latter are to be cast with appropriate extensions to permit connection, through butt-welded joints, to the surrounding structures, and to allow any radiographic and ultrasonic examinations to be easily carried out.

Where required, preheating and stress relieving treatments are to be performed according to the welding procedure specification.

2.3 Vibrations

2.3.1 Shipyards and manufacturers are to give special consideration to the design, construction and installation of propulsion machinery systems and auxiliary machinery so that any mode of their vibrations shall not cause undue stresses in this machinery in the normal operating ranges.

2.4 Operation in inclined position

2.4.1 Main propulsion machinery and all auxiliary machinery essential to the propulsion and the safety of the yacht are, as fitted in the yacht, be designed to operate when the yacht is upright and when inclined at any angle of list either way and trim by bow or stern as stated in Tab 1.

The Society may permit deviations from angles given in Tab 1, taking into consideration the type, size and service conditions of the yacht.

Machinery with a horizontal rotation axis is generally to be fitted on board with such axis arranged alongship. If this is not possible, the Manufacturer is to be informed at the time the machinery is ordered.

2.5 Ambient conditions

2.5.1 Machinery and systems covered by the Rules are to be designed to operate properly under the ambient conditions specified in Tab 2, unless otherwise specified in each Section of this Chapter.

2.6 Power of machinery

2.6.1 Unless otherwise stated in each Section of this Chapter, where scantlings of components are based on power, the values to be used are determined as follows:

- for main propulsion machinery, the power/rotational speed for which classification is requested
- for auxiliary machinery, the power/rotational speed which is available in service.

Table 1 : Inclination of yacht

Installations, components	Angle of inclination (degrees) **(1)**			
	Athwartship		Fore and aft	
	static	dynamic	static	dynamic
Main and auxiliary machinery	15	22,5	5	7,5
Safety equipment, e.g. emergency power installations, emergency fire pumps and their devices Switch gear, electrical and electronic appliances **(2)** and remote control systems	22,5 **(3) (4)**	22,5 **(3) (4)**	10	10

(1) Athwartship and fore-and-aft inclinations may occur simultaneously.
(2) Up to an angle of inclination of 45° no undesired switching operations or operational changes may occur.
(3) In sailing yachts, auxiliary engines must operate satisfactorily after being heeled to a larger angle of 30° a long time.
(4) In sailing yachts, where main and/or auxiliary engines are intended to supply energy to a yacht sailing heeled a long time, the subject engines must operate satisfactorily to an angle of 30°.

Table 2 : Ambient conditions

AIR TEMPERATURE	
Location, arrangement	Temperature range (°C)
In enclosed spaces	between 0 and +45 **(1)**
On machinery components, boilers In spaces subject to higher or lower temperatures	according to specific local conditions
On exposed decks	between –25 and +45 **(2)**
(1) Different temperatures may be accepted by the Society in the case of yachts intended for restricted service. **(2)** Electronic appliances are to be designed for an air temperature up to 55°C (for electronic appliances see also Part C, Chapter 2).	

WATER TEMPERATURE	
Coolant	Temperature (°C)
Sea water or, if applicable, sea water at charge air coolant inlet	up to +32

2.7 Astern power

2.7.1 Where power exceeds 5 kW, means for going astern is to be provided to secure proper control of the yacht in all normal circumstances.

The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the maximum ahead revolutions for a period of at least 30 min.

For main propulsion systems with reversing gears, controllable pitch propellers or electrical propeller drive, running astern is not to lead to an overload of propulsion machinery.

During the sea trials, the ability of the main propulsion machinery to reverse the direction of thrust of the propeller is to be demonstrated and recorded (see also Ch 1, Sec 10).

2.8 Safety devices

2.8.1 Where risk from overspeeding of machinery exists, means are to be provided to ensure that the safe speed is not exceeded.

2.8.2 Where main or auxiliary machinery including pressure vessels or any parts of such machinery are subject to internal pressure and may be subject to dangerous overpressure, means are to be provided, where practicable, to protect against such excessive pressure.

2.8.3 Where applicable, main internal combustion propulsion machinery and auxiliary machinery are to be provided with automatic shut-off arrangements in the case of failures, such as lubricating oil supply failure, which could lead rapidly to complete breakdown, serious damage or explosion.

The Society may permit provisions for overriding automatic shut-off devices.

See also the specific requirements given in the other Sections of this Chapter.

2.9 Fuels

2.9.1 Fuel oils employed for engines and boilers are, in general, to have a flash point (determined using the closed cup test) of not less than 60°C. However, for engines driving emergency generators, fuel oils having a flash point of less than 60°C but not less than 43°C are acceptable.

For yachts assigned with a restricted navigation notation, or whenever special precautions are taken to the Society's satisfaction, fuel oils having a flash point of less than 60°C but not less than 43°C may be used for engines and boilers, provided that, from previously effected checks, it is evident that the temperature of spaces where fuel oil is stored or employed will be at least 10°C below the fuel oil flash point at all times.

Fuel oil having flash points of less than 43°C may be employed on board provided that it is stored outside machinery spaces and the arrangements adopted are specially approved by the Society.

2.9.2 For ships less than 12 m in length, fuel oils having a flash point less than 43°C could be used for engines with arrangements specially approved by the Society.

3 Arrangement and installation on board

3.1 General

3.1.1 Provision is to be made to facilitate cleaning, inspection and maintenance of main propulsion and auxiliary machinery, including boilers and pressure vessels.

Easy access to the various parts of the propulsion machinery is to be provided by means of metallic ladders and gratings fitted with strong and safe handrails.

Spaces containing main and auxiliary machinery are to be provided with adequate lighting and ventilation.

3.2 Gratings

3.2.1 Gratings in engine rooms, if any, are to be divided into easily removable panels. They are to be metallic for yachts over 500 GT.

3.3 Bolting down

3.3.1 Bedplates of machinery are to be securely fixed to the supporting structures by means of foundation bolts which are to be distributed as evenly as practicable and of a sufficient number and size so as to ensure proper fitting.

Where the bedplates bear directly on the inner bottom plating, the bolts are to be fitted with suitable gaskets so as to ensure a tight fit and are to be arranged with their heads within the double bottom.

Continuous contact between bedplates and foundations along the bolting line is to be achieved by means of chocks of suitable thickness, carefully arranged to ensure a complete contact.

The same requirements apply to thrust block and shaft line bearing foundations.

Particular care is to be taken to obtain levelling and general alignment between the propulsion engines and their shafting (see also Ch 1, Sec 2, [7]).

3.3.2 Chocking resins are to be type approved.

3.3.3 Where stays are provided for fixing the upper part of engines to the yacht's structure in order, for example, to reduce the amplitude of engine vibrations, such stays are to be so designed as to prevent damage to these engines further to deformation of the shell plating in way of the said stays. The stays are to be connected to the hull in such a way as to avoid abnormal local loads on the structure of the yacht.

3.4 Safety devices on moving parts

3.4.1 Suitable protective devices on access restrictions are to be provided in way of moving parts (flywheels, couplings, etc.) in order to avoid accidental contact of personnel with moving parts.

3.5 Gauges

3.5.1 Gauges are to be clearly visible, with indication of type of fluid.

3.6 Ventilation in engine or machinery spaces

3.6.1 Engine or machinery spaces are to be sufficiently ventilated so as to ensure that when machinery or boilers therein are operating at full power in all weather conditions, including heavy weather, a sufficient supply of air is maintained to the spaces for the operation of the machinery.

This sufficient amount of air is to be supplied through suitably protected openings arranged in such a way that they can be used in all weather conditions, taking into account the provisions of Pt B, Ch 2, Sec 2, [3.4].

Special attention is to be paid both to air delivery and extraction and to air distribution in the various spaces. The quantity and distribution of air are to be such as to satisfy machinery requirements for developing maximum continuous power.

The ventilation is to be so arranged as to prevent any accumulation of flammable gases or vapours.

3.7 Hot surfaces and fire protection

3.7.1 Surfaces, having temperature exceeding 60°C, with which the crew are likely to come into contact during operation are to be suitably protected or insulated.

Surfaces of machinery with temperatures above 220°C, e.g. steam, thermal oil and exhaust gas lines, silencers, exhaust gas boilers and turbochargers, are to be effectively insulated with non-combustible material or equivalently protected to prevent the ignition of combustible materials coming into contact with them. Where the insulation used for this purpose is oil absorbent or may permit the penetration of oil, the insulation is to be encased in steel sheathing or equivalent material.

Fire protection, detection and extinction are to comply with the requirements of Part C, Chapter 4.

3.8 Machinery remote control, alarms

3.8.1 For remote control systems of main propulsion machinery and essential auxiliary machinery and relevant alarms and safety systems, the requirements of Ch 3, Sec 2 apply.

3.9 Pressure vessels

3.9.1 Pressure vessels are to be reviewed, constructed, installed and tested in accordance with the applicable requirements of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 3.

The acceptance of national and international standards as an alternative may be considered by the society on a case by case basis.

4 Tests and trials

4.1 Works tests

4.1.1 Equipment and its components are subjected to works tests which are detailed in the relevant Sections of this Chapter. The Surveyor is to be informed in advance of these tests.

Where such tests cannot be performed in the workshop, the Society may allow them to be carried out on board, provided this is not judged to be in contrast either with the general characteristics of the machinery being tested or with particular features of the shipboard installation. In such cases, the Surveyor is to be informed in advance and the tests are to be carried out in accordance with the provisions of NR216 Materials and Welding, relative to incomplete tests.

All boilers, all parts of machinery, all steam, hydraulic, pneumatic and other systems and their associated fittings which are under internal pressure are to be subjected to appropriate tests including a pressure test before being put into service for the first time as detailed in the other Sections of this Chapter.

4.2 Trials on board

4.2.1 Trials on board of machinery are detailed in Ch 1, Sec 10.

Section 2 Propelling and Auxiliary Machinery

1 General Provisions

1.1 Scope

1.1.1 Application

The following requirements apply to the main propulsion and auxiliary machinery.

1.1.2 Operating conditions

a) On motor driven yachts, the propulsive engine and all auxiliary equipment must retain their ability to operate satisfactorily in the operating conditions described in Ch 1, Sec 1, [2.4]

b) On sailing yachts, auxiliary engines must operate satisfactorily when and after being heeled to a larger angle, (30°) even for a long time.

1.2 Documents to be submitted

1.2.1 The documents and drawings detailed hereafter are to be submitted to the Society:

- general arrangement showing engines position and seating
- longitudinal section showing stern-tube line of shaft

  bearing and shaft brackets
- shaftings: general dispositions and details
- propellers
- diagrammatic arrangement of fuel, lubricating, cooling, air, starting, exhaust systems, etc. (see Ch 1, Sec 4 to Ch 1, Sec 9).
- torsional vibrations report if required (see Article [6])
- shaft alignment report if required (see Article [7]).

2 Internal combustion engines

2.1 General

2.1.1 Application

The following requirements apply to internal combustion engines used for main propulsion, electric generators including emergency generators and other essential auxiliary machinery for safety and navigation.

2.1.2 Approval

Internal combustion engines listed below are to be designed, constructed, type tested and certified in accordance with the relevant requirements of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 2:

- main propulsion engines, when the power exceeds 220 kW per engine
- engines driving electric generators, including emergency generators, when they develop a power of 110 kW and over
- engines driving other auxiliaries essential for safety and navigation, when they develop a power of 110 kW and over.

For other internal combustion engines, an alternative approval scheme could be accepted after satisfactory review of the following to be submitted documents:

- type test report
- drawing of crankshaft
- engine documentation
- justifications of marine application of the engine.

2.2 Installation

2.2.1 Instruction manual

An instruction manual is to be provided with every engine. As a rule, this one is to indicate:

a) the maximum engine power
b) the total dry engine mass, including all standard accessories as described by the manufacturer
c) installation instructions
d) the maximum and minimum allowable rotational speeds at full throttle, the maximum continuous rated speed, and the allowable maximum number of hours overspeed per 24 hours
e) fuel requirements, including the type of fuel
f) lubricating requirements for the engine and transmission including running-in instructions, recommended maximum and minimum oil pressures, capacities of sump and gearbox and recommended types of oil
g) recommended jacket cooling water temperatures for either fresh-water-cooled or salt-water-cooled engines. Flow diagram for the cooling water system. Details on inhibitors to be used in closed-circuit cooling systems
h) starting instructions and trouble shooting guide
i) complete instructions for laying-up the engine, including the location of all drain plugs
j) a wiring diagram of the engine electrical system, including an indication of the ground polarity where the accessories are grounded
k) air compressed or battery requirement for starting
l) a list of recommended emergency spares and tools
m) information for emergency maintenance if the engine becomes submerged (outboard engine).

2.2.2 Engine components and accessories arrangement

a) The arrangement of component parts of the engine is to be in accordance with the installation instructions; the attached equipment is to be accessible, without the use of tools, for normal maintenance of the engine (e.g. oil fills, dip sticks, cooling water fills).
b) Engine accessories and equipment are to be manufactured and installed so that they can be serviced and lubricated as required and recommended.

2.2.3 Lubricating oil

Provision is to be made for removal of substantially all of the oil from the engine sump without spillage of oil into the bilge. Means are to be provided to determine the correct oil level in the engine as it is installed.

2.2.4 Safety devices on moving parts

All exposed belt drives, chain drives and rotating parts, as installed, are to be covered with guards or are to be designed in such a way as to prevent injury during the normal operation of the engine. An engine box shall be accepted for the purpose of this paragraph. Maintenance or engine repairing are not considered normal operation. Belts are to be changeable without dismantling any major part of the engine.

2.2.5 Hot surfaces protections

Protective guards, jacketing, or engine boxes are to be provided whenever persons or gear might come in contact with the engine or its components as installed in normally occupied spaces, where their temperature exceeds 90°C.

2.2.6 Piping systems

Fuel, lubricating oil, cooling systems are to be in accordance with the relevant provisions of Ch 1, Sec 4 to Ch 1, Sec 9.

2.2.7 Drip tray and gutterways

In wooden yachts, a suitable drip tray wider and longer than the engine and gear box must be fitted to collect leakage of fuel and lubricating oil. Where fitted, it should be of such size and depth as to collect oil which may fall from the engine when the yacht is pitching or heavily heeling.

In yachts built in composite material or metal, a drip tray is not essential provided that the transverse and longitudinal bearers form any oil-tight box section compartment of the above mentioned extent. For yachts built in composite material, care must be taken to ensure that fibres are well covered.

2.2.8 High pressure fuel oil lines

All external high pressure fuel delivery lines between the high pressure fuel pumps and the fuel injectors are to be protected with a shielded piping system capable of containing fuel from high pressure line failure.

A shielded pipe incorporates an outer pipe into which the high pressure fuel pipe is placed forming a permanent assembly.

For engines with a maximum rated power of 375 kW fitted on board of yachts with a restricted navigation, alternative means of protection could be accepted, e.g. protective screens.

2.3 Engine seating and fixing

2.3.1 Seating and fixing for inboard engine

a) The seatings are to be of robust construction and adequately attached to the hull. They are to be so designed and arranged that they can withstand the various stresses they are subjected to, without detrimental deformations to the machines they are supporting. Provision is to be made, as far as practicable, to ensure continuity between the longitudinal and transverse elements of the seatings and the corresponding elements of the adjacent hull, also to prevent sudden variations of inertia.

b) Engine bearers must be of ample size and extend as far forward and aft as is practicable. Where engines are of relatively high power the girders must extend beyond the engine space bulkheads and into the bottom framing system. Built-up engine seatings must be effectively supported both longitudinally and transversely.

c) Particular attention is to be paid to the arrangement of thrust-bearing seatings and their attachment to the hull.

d) Engines are to be so fixed to their seatings as to prevent any displacement due to the movements of the yacht.

e) Where stays are provided for fixing the upper part of engines to the yacht's structure in order, for example, to reduce the amplitude of engine vibrations, such stays are to be so designed as to prevent damage to these engines further to deformation of the shell plating in way of said stays. The stays are to be connected to the hull in such a way as to avoid abnormal local loads on the structure of the yacht.

f) Accessories of engines as well as spare parts of large dimensions are to be strongly secured so that they cannot move or become loose under the yacht's movements.

g) Where resilient mountings are fitted, the output shaft is to be connected to the propeller shaft through a flexible coupling. Satisfactory arrangements are to be made to transmit thrust, and flexibility is to be provided in all fuel, water, exhaust lines and electrical cables.

h) Where resilient mountings are fitted, the permissible radial shaft displacement of the flexible coupling must not be exceeded.

2.3.2 Installation of outboard engines

a) A watertight and self-draining motor well is to be designed into the transom of all outboard engine yachts.

b) The strength and rigidity of the transom should be related to the thrust imposed by the propeller and its resultant moment imposed upon the transom under dynamic loads.

   For yachts built in composite materials and except for engines of very low power, the transom is to be, as a general rule, of sandwich construction having a core of waterproof plywood or of equivalent strength. The internal skin of the sandwich must be of thickness not less than that of the yacht side skin, and the outer skin not less than that of the bottom. The internal skin is to be carried well forward along the sides and bottom of the yacht and gradually tapered in thickness towards its edges.

   Protective plates should be fitted in way of engine fixing clamps.

c) Outboard engines should be capable of being fastened to the hull with through belts, chains or other safety dispositions.

2.4 Starting systems

2.4.1 Compressed air system

Where internal combustion engines are started by means of compressed air, the requirements of Ch 1, Sec 9, [6] regarding the number and position of compressors as well as the arrangement of compressed air systems are to be complied with.

2.4.2 Electric starting system

Where internal combustion engines are fitted with electric starting, the requirements stated in Part C, Chapter 2 are to be complied with.

2.4.3 Emergency system

Where suitable emergency manual starting means are provided, attenuation to these requirements may be considered by the Society.

2.5 Control, safety, monitoring and instrumentation

2.5.1 Control systems

a) Components of the propulsion control system are to be suitably resistant to corrosion, either by virtue of material or coating thereof, and galvanically compatible with each other.

b) On a twin-engine yacht, the throttle controls should be located so that both engines can be throttled with one hand.

c) Where control cables are used, they are to be installed with as few bends as possible. Bends are to have as large a radius as possible and the radius is not to be smaller than the manufacturer's recommended minimum. The route of the cables are to be direct and uncrowded by accessory equipment.

   The primary control actuation is to be through a lever and not a knob directly attached to the end of the cable.

2.5.2 Safety arrangements

a) Except where duly justified, a means for operating the throttle without engaging the gears is to be provided for all yachts exceeding 5 kW in shaft power. To ensure this, it should not be possible to start the motor unless the shift control is in neutral position.

b) Non-propulsion engines intended for automatic operation are to be fitted with an automatic shutdown device actuated by low oil pressure.

c) Engine crankcases are to be sufficiently vented to prevent excessive pressurization.

Diesel engines of a cylinder diameter of 200 mm and above or a crankcase gross volume of 0,6 m^3 are to be provided with crankcase explosion relief valves.

Diesel engines of a cylinder diameter of 300 mm and above or a power of 2250 kW and above are to be provided with oil mist detection.

Note 1: As a rule, when fitted, crankcase explosion relief valves and oil mist detection are to be in accordance with the provisions of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 2.

d) Each outboard engine is to be provided with a tilt mechanism which shall operate when the driveleg comes into contact with an obstruction. Adequate means are to be provided to adjust the force required to activate the tilt mechanism.

e) Carburetors are to be fitted with a drainage of fuel leakage in the inlet pipe system and fitted with flame arresting device.

2.5.3 Governors of main and auxiliary engines

Each engine, except the auxiliary engines for driving electric generators for which [2.5.4] applies, is to be fitted with a speed governor so adjusted that the engine does not exceed the rated speed by more than 15%.

2.5.4 Overspeed protective devices of main and auxiliary engines

In addition to the speed governor, each:

- main propulsion engine having a rated power of 220 kW and above, which can be declutched or which drives a controllable pitch propeller, and
- auxiliary engine having a rated power of 220 kW and above, except those for driving electric generators for which [2.5.6] applies,

is to be fitted with a separate overspeed protective device so adjusted that the engine cannot exceed the rated speed n by more than 20%; arrangements are to be made to test the overspeed protective device.

Equivalent arrangements may be accepted subject to special consideration by the Society in each case.

The overspeed protective device, including its driving mechanism or speed sensor, is to be independent of the governor.

2.5.5 Governors for auxiliary engines driving electric generators

a) Auxiliary engines intended for driving electric generators are to be fitted with a speed governor which prevents any transient speed variations in excess of 10% of the rated speed when the rated power is suddenly thrown off or specific loads are suddenly thrown on.

b) At all loads between no load and rated power, the permanent speed variation is not to be more than 5% of the rated speed.

c) Prime movers are to be selected in such a way that they meet the load demand within the ship's mains and, when running at no load, can satisfy the requirement in item a) above if suddenly loaded to 50% of the rated power of the generator, followed by the remaining 50% after an interval sufficient to restore speed to steady state. Steady state conditions (see Note 1) are to be achieved in not more than 5 s. (See Note 1).

d) Application of the electrical load in more than 2 load steps can only be allowed if the conditions within the ship's mains permit the use of those auxiliary engines which can only be loaded in more than 2 load steps (see Fig 1 for guidance) and provided that this is already allowed for in the designing stage.

This is to be verified in the form of system specifications to be approved and to be demonstrated at ship's trials. In this case, due consideration is to be given to the power required for the electrical equipment to be automatically switched on after blackout and to the sequence in which it is connected.

This also applies to generators to be operated in parallel and where the power is to be transferred from one generator to another, in the event that any one generator is to be switched off.

e) When the rated power is suddenly thrown off, steady state conditions should be achieved in not more than 5 s.

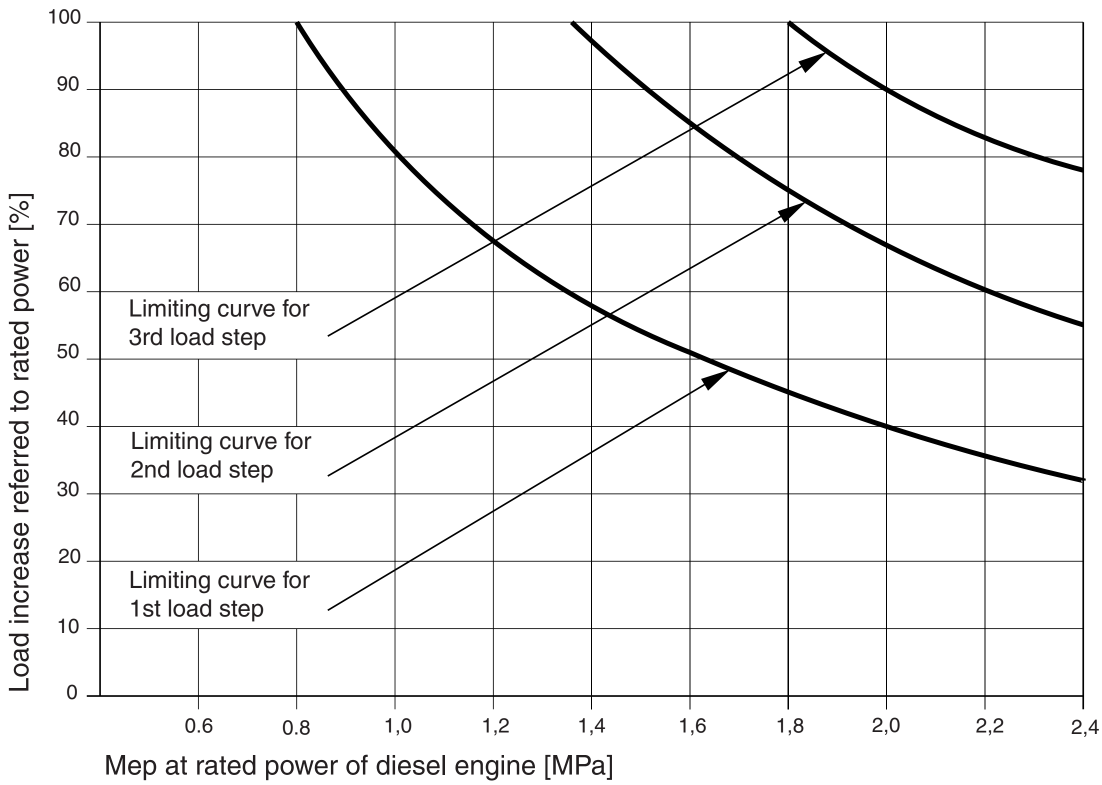
f) Emergency generator sets must satisfy the governor conditions as per items a) and b) when:
   - their total consumer load is applied suddenly, or
   - their total consumer load is applied in steps, subject to the maximum step load is declared and demonstrated.

g) For alternating current generating sets operating in parallel, the governing characteristics of the prime movers are to be such that, within the limits of 20% and 100% total load, the load on any generating set will not normally differ from its proportionate share of the total load by more than 15% of the rated power in kW of the largest machine or 25% of the rated power in kW of the individual machine in question, whichever is the lesser.

For alternating current generating sets intended to operate in parallel, facilities are to be provided to adjust the governor sufficiently finely to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

Note 1: Steady state conditions are those at which the envelope of speed variation does not exceed ± 1% of the declared speed at the new power.

Figure 1 : Limiting curves for loading 4-stroke diesel engines step by step from no load to rated power as a function of the brake mean effective pressure



2.5.6 Overspeed protective devices of auxiliary engines driving electric generators

In addition to the speed governor, auxiliary engines of rated power equal to or greater than 220 kW driving electric generators are to be fitted with a separate overspeed protective device, with a means for manual tripping, adjusted so as to prevent the rated speed from being exceeded by more than 15%.

This device is to automatically shut down the engine.

2.5.7 Use of electronic governors

a) Type approval

   Electronic governors and their actuators are to be type approved by the Society.

b) Electronic governors for main propulsion engines

   If an electronic governor is fitted to ensure continuous speed control or resumption of control after a fault, an additional separate governor is to be provided unless the engine has a manually operated fuel admission control system suitable for its control.

   A fault in the governor system is not to lead to sudden major changes in propulsion power or direction of propeller rotation.

   Alarms are to be fitted to indicate faults in the governor system.

   The acceptance of electronic governors not in compliance with the above requirements will be considered by the Society on a case by case basis, when fitted on ships with two or more main propulsion engines.

c) Electronic governors for auxiliary engines driving electric generators

   In the event of a fault in the electronic governor system the fuel admission is to be set to "zero".

   Alarms are to be fitted to indicate faults in the governor system.

   The acceptance of electronic governors fitted on engines driving emergency generators will be considered by the Society on a case by case basis.

2.5.8 Engine monitoring for propulsion engine and generating set

a) For diesel engine of 1000 kW and above:

   The requirements laid down in Tab 2, Tab 3 and Tab 4 of the Rules for Steel Ships, Pt C, Ch 1, Sec 2 apply

b) For diesel engine with power less than 1000 kW:

   Engines installed on ships are to be equipped with monitoring equipment as detailed in Tab 1.

Table 1 : Monitoring

Symbol convention H = High, HH = High high, L = Low, LL = Low low, X = function is required.	Monitoring		Automatic control
Indication of system parameter	Alarm	Indication	Shutdown
Lub oil pressure	L	Local	
	LL **(1)**		X **(1)**
Fresh water temperature	H	Local	
Engine speed	H **(1)**	Local	X **(1)**

(1) The alarm and the associated shutdown can use the same sensor.
Note 1: The indicators are to be fitted at a normally attended position (on the engine or at local control station).
Note 2: The alarms are to be visual and audible at a normally attended position (on the engine or at local control station).
Note 3: All these alarms are to be indicated at least at the navigational bridge as general alarm.
Note 4: For diesel engines with power less than 220kW, automatic controls are not required for propulsion engines of ships with more than one propulsion plant.

3 Reduction gear - Transmission

3.1 General

3.1.1 Design

Reduction gear and transmissions are to be of marine type and suitably matched to the engine with which they are to be used.

3.1.2 Approval

Where the power per shaft line exceeds 220 kW, reduction gear and transmissions are to be in compliance with the relevant requirement of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 6, with the design factors listed in [3.2.1].

3.2 Design and construction

3.2.1 Design

The reduction gear should normally be designed and built in accordance with the relevant provisions of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 6. However, coefficients SH and SF considered for the determination of respectively the permissible contact stress and the permissible tooth root bending stress are as follows:

SH : Acceptance factor for contact stress. The value of SH is 1,10 for single and duplicate machinery

SF : Acceptance factor for tooth root bending stress. The value of SF is 1,45 for single machinery and 1,40 for duplicate machinery.

3.2.2 Overspeed

As a rule, the reduction gear is to be able to withstand momentary overspeeds of 115% of the maximum rated engine speed in forward and reverse.

3.2.3 Lubricating oil

Reduction gear incorporating an independent oiling system is to include a suitable oil sump, an oil level indicating device, and a vent located to provide adequate breathing, but positioned to prevent oil leakage from the transmission under normal operating conditions.

3.2.4 Cooling

Reduction gear and transmissions are to be provided with a method of cooling so that recommended maximum sump temperatures will not be exceeded under normal operating conditions.

3.2.5 Monitoring

Hydraulically actuated transmissions are to have a provision to monitor oil pressure and/or oil temperature.

4 Shafting

4.1 General

4.1.1 Application

a) Scantling rules mentioned in this Section are applicable to propulsion shaft line, whatever the power per shaft may be.

b) For shafting components in engines, gears and main propulsion thrusters, refer to the relevant requirements of NR467 Rules for Steel Ships, Pt C, Ch 1, respectively Sec 2, Sec 6 and Sec 12.

4.1.2 Materials

Materials used for elements covered by this Section should, as a rule, comply with the requirements of NR216 Materials and Welding. Use of other materials are to be subject to special examination.

4.2 Shafting scantling

4.2.1 Materials

The present Sub-article is applicable to propeller shaft built in materials defined in Tab 2. Propeller shaft built in composite materials are to examined according to NR546 Hull in composite materials.

4.2.2 Propeller shaft diameter

a) The diameter of the shaft going through the stern tube is not to be less than the diameter d, in mm, given by the following formula:

$d = K (P / N)^{1/3}$

where:

P : Brake power, in kW

N : Shaft revolutions per minute

K : Coefficient having the values given in Tab 2.

Furthermore, the shaft diameter is not to be less than 25 mm for carbon steel or carbon manganese steel, and 20 mm for the other materials listed in Tab 2.

The use of materials other than those included in Tab 2 is to be subject to special examination.

b) When the propeller shaft is made out of carbon manganese steel and is protected by a continuous liner or by oil lubrication with approved oil sealing gland, coefficient K is given by the following formula:

$K = 126 [560 / (R_m + 160)]^{1/3}$

where:

R_m : Value of the minimum tensile strength of the shaft material, in N/mm². The value of R_m to be introduced in the formula is not to be taken higher than 600 N/mm².

Table 2 : Values of coefficient K

Material	R_{eH} mini, in N/mm²	R_m mini, in N/mm²	K
Carbon and carbon manganese steel	200	400	126
Austenitic stainless steel (type 316)	175	470	91
Manganese bronze	245	510	92
Martensitic stainless steel (type 431)	675	850	88
Ni-Al bronze	390	740	85
Nickel-copper alloy (Monel 400)	350	550	85
Nickel-copper alloy (Monel K 500)	690	960	71
Duplex stainless steel (Type S31803)	450	650	63

4.2.3 Intermediate shaft diameter

The diameter, in mm, of the intermediate shafts is not to be less than:

$d' = 0,8 K (P / N)^{1/3}$

where P, N and K are defined in [4.2.2].

4.2.4 Hollow shaft

Where hollow shafts are used the required diameter determined according to the formulas given in [4.2.1] and [4.2.2] are to be multiplied by the factor Kd as indicated in Tab 3, where:

Q : Ratio of the internal diameter to the outer shaft diameter.

A central hole with Q less than 0,4 may be accepted without increase in shaft size.

Table 3 : Values of coefficient Kd

Q	0,4	0,5	0,6	0,7
Kd	1,01	1,02	1,05	1,10

4.2.5 Cardan shaft

Characteristics of the cardan shaft and justification of the cardan shaft life duration are to be submitted for information.

4.3 Shafting accessories

4.3.1 Coupling flanges

a) The thickness of inboard coupling flanges, at the pitch circle of the bolt holes, is not to be less than the required diameter of the corresponding bolts determined as indicated in [4.3.2], paying due regard to the specified minimum tensile strength of the material of said flanges. Besides, the thickness of the propeller shaft coupling flange is not to be less than 0,20 times the required diameter of the intermediate shaft, calculated paying due regard to the specified minimum tensile strength of the material of said flange.

   The fillets of coupling flanges at their junction with the shafts are to have a radius at least equal to 8% of the diameter of the corresponding shaft.

b) Outboard coupling flanges are to have a thickness not less than 0,25 times the required diameter of the corresponding shaft. The fillet radius at the junction with the shaft is not to be less than half the required thickness of the flange.

c) The fillets are to be carefully machined and, as a rule, recesses are to be avoided as far as possible in way of bolt heads and nuts.

4.3.2 Coupling bolts

a) The diameter of coupling bolts at the joining faces of the couplings is to be not less than the diameter D_b given, in mm, by the following formula, for intermediate, propeller and thrust shafts:

$$D_b = 11.10^3\left(\frac{P}{n \cdot r \cdot Rb \cdot N}\right)^{1/2}$$

   where:

   n : Number of bolts in the coupling

   r : Radius of the pitch circle of the bolts, in mm

   Rb : Ultimate tensile strength of the bolt metal, in N/mm^2

   P : As defined in [4.2.2]

   N : As defined in [4.2.2].

b) For the fitted bolts of coupling flanges for crankshaft parts as well as of coupling flanges between crankshafts and thrust and flywheel-shafts, the above formula is to be applied but the factor $11 \cdot 10^3$ is to be superseded by $14 \cdot 10^3$.

c) Flange coupling with non-fitted coupling bolts may be accepted on the basis of the calculation of bolts tightening, bolts stress due to tightening and assembly construction. Refer to relevant requirements of the NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 7, [2.5.1].

d) Where the pieces of the shafting are not joined by means of forged coupling flanges, the arrangement will be given special consideration by the Society; in this case, provision is to be made for the coupling to resist the rated astern pull.

e) Where the shafts have peculiar machining such as grooves, longitudinal slots or transverse holes the design is to be such as to reduce stress concentrations. A local increase of the shaft diameter may be required by the Society.

4.3.3 Shaft liners

a) Propeller shafts of carbon steel are to be protected by a continuous salt water resistant liner where exposed to sea water. Alternatively, the liner may be omitted provided the shaft runs in an oil lubricated stern tube with an approved sealing gland at the after end. Length of shafting between stern tube and propeller bracket may be protected by suitable coatings.

b) The thickness of bronze shaft liners in way of the bushes and sterngland is to be not less than the thickness e, in mm, given by the following formula:

$$e = \frac{d + 230}{32}$$

   where:

   d : Actual diameter of the propeller shaft, in mm.

c) The thickness of the continuous liner between the bushes is to be not less, as a rule, than 0,75 e.

   The liners are considered as continuous when they are:

   - either cast in one piece, or
   - made of two or more lengths assembled by joints of an approved type.

d) Where parts of liners are assembled by welding, arrangements are to be made to protect the surface of the shaft during welding and to allow the free contraction of the joint after welding.

e) The joints between liner parts are not to be located in way of the bushes or sterngland.

f) Each continuous liner or length of liner is to be tested by hydraulic pressure to 2 bars after rough machining.

g) Liners are to be carefully shrunk on the shafts either whilst hot, or by hydraulic press, or by any other approved process. Pins or other similar devices are not to be used to secure the liners on the shafts.

h) Where ways are provided between liner and propeller shaft outside the bearings, these ways are to be filled with a material insoluble in water and non-corrosive.

i) Means are to be provided, particularly at the junction of liner and propeller boss, to prevent any entry of sea water under the liner and on the propeller boss.

4.3.4 Stern tube bearings

a) Oil lubricated bearings of white metal

The length of white metal lined bearings is to be not less than 2,0 times the rule diameter of the shaft in way of the bearing.

The length of the bearing may be less than that given above, provided the nominal bearing pressure is not more than 0,8 N/mm^2, as determined by static bearing reaction calculations taking into account shaft and propeller weight, as exerting solely on the aft bearing, divided by the projected area of the shaft.

However, the minimum bearing length is to be not less than 1,5 times its actual inner diameter.

b) Oil lubricated bearings of synthetic rubber, reinforced resin or plastic materials

For bearings of synthetic rubber, reinforced resin or plastic materials which are approved for use as oil lubricated stern bush bearings, the length of the bearing is to be not less than 2,0 times the rule diameter of the shaft in way of the bearing.

The length of the bearing may be less than that given above provided the nominal bearing pressure is not more than 0,6 N/mm^2, as determined according to item a).

However, the minimum length of the bearing is to be not less than 1,5 times its actual inner diameter.

Where the material has proven satisfactory testing and operating experience, consideration may be given to an increased bearing pressure.

c) Water lubricated bearings of synthetic materials

Where the bearing is constructed of synthetic materials which are approved for use as water lubricated stern bush bearings, such as rubber or plastics, the length of the bearing is to be not less than 4,0 times the rule diameter of the shaft in way of the bearing

For a bearing design substantiated by experiments to the satisfaction of the Society, consideration may be given to a bearing length not less than 2,0 times the rule diameter of the shaft in way of the bearing.

d) Other arrangements

The other arrangements beside those defined in items a), b) and c) are to be given special consideration. The length of the after bearing of the propeller shaft is to be not less than 4,0 times the rule diameter of the shaft in way of the bearing.

e) Where the bearings are lubricated by water, arrangements are to be made for an adequate supply of water.

A forced water lubrication is to be provided, if necessary, namely for bearings lined with lignum vitae, rubber or plastic materials.

f) For oil lubricated bearings and where the lubrication is made by gravity, the lubricating oil tank is to be located above the load centre water line. In this case, a low level indication or preferably an alarm is to be given at the operator's position.

4.3.5 Sealing glands

a) The sealing glands must be readily accessible, for inspection or replacement.

b) The sealing glands are to be periodically inspected.

c) It is to be mentioned in the Owner's manual, all necessary measures to be taken in case of accidental breaking of a main element, as well as the periodicity of inspections and replacement of elements subject to deterioration or wearing.

d) The wear strength of non-metallic parts is to be established, either by satisfactory operations, or by relevant tests.

An easy-to-fit emergency device may be accepted.

4.3.6 Propeller shaft keys and keyways

See relevant requirements of the NR467 Rules for Steel Ships, Pt C, Ch1, Sec 7, [2.2.5].

5 Propeller

5.1 Scantlings

5.1.1 Propeller scantlings are to comply with the requirements of the Rules for Steel Ships, Pt C, Ch 1, Sec 8.

5.1.2 The Society may agree, for propellers, scantlings justified by either adequate calculations, or satisfactory experience in service.

6 Shaft vibrations

6.1 General

6.1.1 Application

A torsional vibration calculation is to be submitted for review for the shafting of the following installation in compliance with the relevant requirement of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 9:

- propulsion systems with prime movers developing 220 kW or more
- other systems with internal combustion engines developing 110 kW or more and driving auxiliary machinery intended for essential services.

7 Shaft alignment

7.1 General

7.1.1 Application and calculation requirements

The applicable requirements of the Rules for Steel Ships, Pt C, Ch 1, Sec 7, [3.3] and Pt C, Ch 1, Sec 7, [3.4] apply.

8 Thrusters and waterjets

8.1 General

8.1.1 Thrusters and waterjets developing power equal to 110 kW or more

Thrusters and waterjets, developing power equal to 110 kW or more intended for propulsion and steering are to be in compliance with the relevant requirements of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 12.

8.1.2 Thrusters and waterjets developing power less than 110 kW

Thrusters and waterjets, developing power less than 110 kW intended for propulsion and steering are to built in accordance with sound marine practice.

Section 3 Steering Gear

1 General

1.1 Application

1.1.1 Scope

Unless otherwise specified, the requirements of this Section apply to the design arrangements, control systems, construction and testing of installations intended for rudder operation, and to the steering mechanism of thrusters used as means of propulsion.

However, the Society may accept, in particular for yachts of less than 24 m in length, arrangements deemed equivalent, notably taking into account the national regulations in force or the provided service and navigation notations.

a) The attention of Interested Party is drawn to the necessity of considering requirements particular to the yacht's flag Authority.

b) Provisions equivalent to the requirements of this Section can be accepted, depending on the Society's agreement.

1.1.2 Cross references

In addition to those provided in this Section, steering gear systems are also to comply with the requirements of:

- Ch 1, Sec 10, as regards sea trials
- Pt B, Ch 7, Sec 2, as regards the rudder and the rudder stock.

1.2 Documentation to be submitted

1.2.1 Documents to be submitted for all steering gear

Before starting construction, all plans and specifications listed in Tab 1 are to be submitted to the Society for approval.

Table 1 : Documents to be submitted for steering gear

No.	A/I **(1)**	Description of the document **(2)**
1	I	Assembly drawing of the steering gear including sliding blocks, guides, stops and other similar components
2	I	General description of the installation and of its functioning principle
3	I	Operating manuals of the steering gear and of its main components
4	I	Description of the operational modes intended for steering in normal and emergency conditions
5	A	For hydraulic steering gear, the schematic layout of the hydraulic piping of power actuating systems, including the hydraulic fluid refilling system, with indication of the: • design pressure • maximum working pressure expected in service • diameter, thickness, material specification and connection details of the pipes • hydraulic fluid tank capacity • flash point of the hydraulic fluid
6	I	For hydraulic pumps of power units, the assembly longitudinal and transverse sectional drawings and the characteristic curves
7	A	Assembly drawings of the rudder actuators and constructional drawings of their components, with, for hydraulic actuators, indication of the: • design torque • maximum working pressure • relief valve setting pressure
8	I	Constructional drawings of the relief valves for protection of the hydraulic actuators, with indication of the: • setting pressure • relieving capacity
9	A	Diagrams of the electric power circuits
10	A	Functional diagram of control, monitoring and safety systems including the remote control from the navigating bridge, with indication of the location of control, monitoring and safety devices
11	A	Constructional drawings of the strength parts providing a mechanical transmission of forces to the rudder stock (tiller, quadrant, connecting rods and other similar items), with the calculation notes of the shrink-fit connections
12	I/A	For azimuth thrusters used as steering means, the specification and drawings of the steering mechanism and, where applicable, documents N°2 to N°6 and N°8 to N°11 above

(1) Submission of the drawings may be requested: for approval, shown as “A”; for information, shown as “I”.

(2) Constructional drawings are to be accompanied by the specification of the materials employed and, where applicable, by the welding details and welding procedures.

1.3 Definitions

1.3.1 Main steering gear

Main steering gear is the machinery, rudder actuators, steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the yacht under normal service conditions.

1.3.2 Auxiliary steering gear

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the yacht in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

1.3.3 Types of steering gear

Main and auxiliary steering gear can be:

- electric, when both the power source and the rudder torque transmission is electric
- electrohydraulic, when the power source is electric and the rudder torque transmission is hydraulic
- engine hydraulic, when the power source is an internal combustion engine and the rudder torque transmission is hydraulic
- manual hydraulic, when the power source is human force and the rudder torque transmission is hydraulic
- manual mechanic, when the power source is human force and the rudder torque transmission is mechanic.

1.3.4 Steering gear power unit

Main and auxiliary steering gear power unit is:

- in the case of electric steering gear, an electric motor and its associated electrical equipment
- in the case of electrohydraulic steering gear, an electric motor and its associated electrical equipment and connected pump
- in the case of engine hydraulic steering gear, a driving engine and connected pump
- in the case of manual hydraulic steering gear, a hand pump (could be combined with a steering wheel)
- in the case of manual mechanic steering gear, a steering wheel (main steering gear) or manual lever on top of rudder stock (auxiliary steering gear).

1.3.5 Power actuating system

Power actuating system is the equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components, i.e. tiller, quadrant and rudder stock, or components serving the same purpose.

1.3.6 Rudder actuator

Rudder actuator is the component which directly converts hydraulic pressure into mechanical action to move the rudder.

1.3.7 Steering gear control system

Steering gear control system is the equipment by which orders are transmitted from the navigation bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

1.3.8 Maximum ahead service speed

Maximum ahead service speed is the greatest speed which the yacht is designed to maintain in service at sea.

1.3.9 Maximum astern speed

Maximum astern speed is the speed which it is estimated the yacht can attain at the designed maximum astern power.

1.3.10 Maximum working pressure

Maximum working pressure is the maximum expected pressure in the system when the steering gear is operated to comply with the provisions of [3.2.1].

1.3.11 Design pressure

Design pressure is the greatest of the following pressures:

- 1,25 times the maximum working pressure
- the setting pressure of the relief valves.

1.4 Symbols

1.4.1 The following symbols are used for strength criteria of steering gear components:

VAV	:	Maximum service speed, in knots, as defined in Pt B, Ch 7, Sec 2
d_s	:	Rule diameter of the rudder stock in way of the tiller, in mm, defined in Pt B, Ch 7, Sec 2 and calculated with a material factor k = 1
d_{se}	:	Actual diameter of the upper part of the rudder stock in way of the tiller, in mm (in the case of a tapered coupling, this diameter is measured at the base of the assembly)

σ : Normal stress due to bending moments and tensile/compression forces, in N/mm²

τ : Shear stress due to torsional moments and shear forces, in N/mm²

σ_a : Permissible stress (Von Mises), in N/mm²

σ_c : Combined stress, determined by the following formula:

$$\sigma_c = \sqrt{\sigma^2 + 3\tau^2}$$

k : Material factor, as defined in Pt B, Ch 7, Sec 2, [1.3.1].

2 Design and construction - Requirements applicable to all yachts

2.1 Mechanical systems

2.1.1 General

a) All steering gear components and the rudder stock are to be of sound and reliable construction to the satisfaction of the Society.

b) Any non-duplicated essential component is, where appropriate, to utilise anti-friction bearings, such as ball bearings, roller bearings or sleeve bearings, which are to be permanently lubricated or provided with lubrication fittings.

c) The construction is to be such as to minimise local concentration of stress.

d) Mechanical components of the steering gear are to be of adequate strength to transmit the rudder torque to the rudder stock and to resist to the loads induced by the steering gear power unit as per [2.1.3].

2.1.2 Materials and welds

a) All steering gear components transmitting mechanical forces to the rudder stock (such as tillers, quadrants, or similar components) are to be made of steel or other approved ductile material complying with the requirements of NR216 Materials and Welding. In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm².

b) The use of grey cast iron is not permitted, except for redundant parts with low stress level, subject to special consideration by the Society. It is not permitted for cylinders.

c) The welding details and welding procedures are to be submitted for approval.

d) All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be full penetration type or of equivalent strength.

2.1.3 Scantling of components

The scantlings of steering gear components are to be determined considering the design torque M_T and the permissible stresses σ_a defined as follows:

a) For all components: $M_T = M_{TR}$, in kN·m

with:

M_{TR} : As defined in Pt B, Ch 7, Sec 2, [2.2]

$$\sigma_a = \frac{118}{k} \text{ for steel}$$

$$\sigma_a = \frac{56}{k} \text{ for aluminum alloy}$$

b) For all components which are subject to loads induced by the steering gear power unit, M_T is calculated considering the steering gear pushed against the mechanical rudder stops by the power unit. The following permissible stresses are to be taken into account:

$$\sigma_a = \frac{148}{k} \text{ for steel}$$

$$\sigma_a = \frac{70}{k} \text{ for aluminium}$$

For example, for electrohydraulic steering gear, the design torque will be based on an actuator force taking into account the design pressure and a lever resulting from a position where the steering gear is positioned against the mechanical rudder stops.

c) For all components in manual steering gear used as auxiliary steering gear the following rudder torque M_T can be taken into account:

$$M_T = \left(\frac{V_E}{V}\right)^2 \cdot M_{TR}$$

where:

- $V_E = 7$ where $V_{AV} \leq 14$
- $V_E = 0{,}5\ V_{AV}$ where $V_{AV} > 14$

The permissible stresses and M_{TR} as indicated in item a) are to be used.

2.1.4 Tillers and quadrants

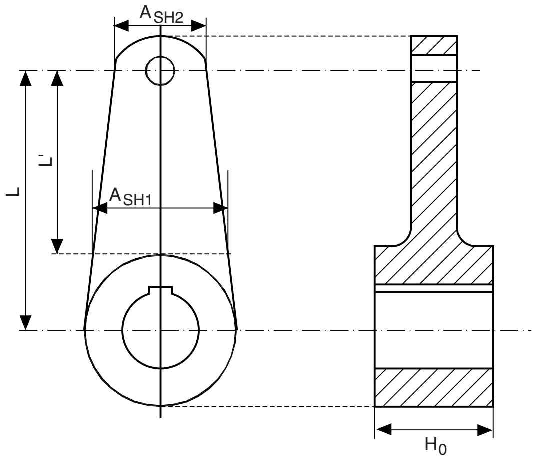
a) The scantling of tillers and quadrants is to be determined as follows:

- the depth H_0 of the boss is not to be less than $0{,}75 \cdot d_s$
- the scantlings are to be designed by direct calculation in accordance with [2.1.3] and the following equation:

  $\sigma_c \leq \sigma_a$

  As an example, for a typical tiller as shown in Fig 1, the following stresses should be taking into account:
  - bending and shear stresses in way of section A_{SH1}
  - shear stresses in way of section A_{SH2}
  - torsional shear stresses in way of tiller boss.

Figure 1 : Tiller arm



b) Keys are to satisfy the following provisions:

- tiller fitted with keys are to be in metallic material
- the key is to be in accordance with the requirements of Pt B, Ch 7, Sec 2, [3.4.2]
- the width of the key is not to be less than $0{,}25 \cdot d_s$
- the thickness of the key is not to be less than $0{,}10 \cdot d_s$
- the ends of the keyways in the rudder stock and in the tiller (or rotor) are to be rounded and the keyway root fillets are to be provided with small radii of not less than 5% of the key thickness.

Note 1: For composite rudder stocks, connection with tiller is, as a rule, carried out without key and is to be examined by the Society on a case by case basis, with direct calculation on all the components of the system.

c) Bolted tillers and quadrants are to satisfy the following provisions:

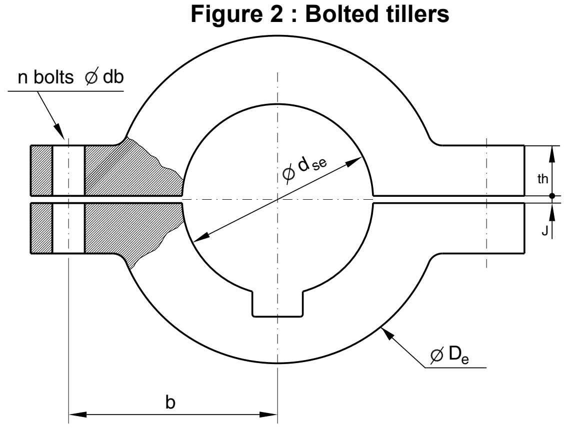
- for arrangement as shown in Fig 2, the bolt diameter is not to be less than the value d_b , in mm, calculated from the following formula:

$$d_b = 153\sqrt{\frac{T_R}{n(b + 0{,}5d_{se})} \cdot \frac{235}{R_{eb}}}$$

where:

n	:	Number of bolts located on the same side in respect of the stock axis (n is not to be less than 2)
b	:	Distance between bolts and stock axis, in mm (see Fig 2)
R_{eb}	:	Yield stress, in N/mm², of the bolt material.

Figure 2 : Bolted tillers



- for other arrangement, direct calculations are to be made to check the following stresses in bolts:
  - tensile stresses, in N/mm^2, to be less than the allowable tensile stress of bolt material
  - shear stresses, in N/mm^2, to be less than the allowable shear stress of bolt material.
- thickness of each tightening flange of the two parts of the tiller is not to be less than the following value:

  $$1,85 \cdot d_b \cdot \sqrt{\frac{n \cdot (b - 0,5 \cdot D_e)}{H_0} \cdot \frac{R_{eb}}{R_{eH}}}$$

  where:

  D_e : External boss diameter, in mm (average value)

  R_{eH} : As defined in Pt B, Ch 7, Sec 2, [1.3.1].
- in order to ensure the efficient tightening of the coupling around the stock, the two parts of the tiller are to bored together with a shim having a thickness not less than the value j, in mm, calculated from the following formula:

  $j = 0,0015\ d_{se}$

  where:

  d_{se} : Actual diameter, in mm, of the upper part of the rudder stock in way of the tiller.

  Special examination for the fitting of such tiller system on hollow section rudder stock is to be carried out.

Note 2: Bolted tillers and quadrants fitted on composite rudder stocks are to be examined by the Society on a case by case basis with direct calculation on all components of the system.

d) Shrink-fit connections of tiller (or rotor) to stock are to satisfy the following provisions:

- materials of rudder stock and tiller are to be made of, respectively, steel and steel or SG cast iron. Other material may be accepted by the Society on a case by case basis.
- the safety factor against slippage is not to be less than:
  - 1,00 for keyed connections
  - 2,00 for keyless connections.
- the friction coefficient is to be taken equal to:
  - 0,15 for steel and 0,13 for spheroidal graphite cast iron, in the case of hydraulic fit
  - 0,17 in the case of dry shrink fitting.
- the combined stress according to the Von Mises criterion, due to the maximum pressure induced by the shrink fitting and calculated in way of the most stressed points of the shrunk parts, is not to exceed 80% of the yield stress of the material considered.

Note 3: Alternative stress values based on FEM calculations may also be considered by the Society.

- the entrance edge of the tiller bore and that of the rudder stock cone are to be rounded or beveled.

2.1.5 Piston rods

The scantling of the piston rod is to be determined taking into account the bending moments, if any, in addition to compressive or traction forces and is to satisfy the following provisions:

a) $\sigma_c \leq \sigma_a$

where:

σ_c : Combined stress as per [1.4.1]

σ_a : Permissible stress as per [2.1.3].

b) in respect of the buckling strength:

$$\frac{4}{\pi D_2^{\ 2}} \cdot \left(\omega F_c + \frac{8M}{D_2}\right) \leq 0,9\sigma_a$$

where:

D_2 : Piston rod diameter, in mm

F_c : Compression force in the rod, in N, when it extends to its maximum stroke

M : Possible bending moment in the piston rod, in N.mm, in way of the fore end of the cylinder rod bearing

ω : $\omega = \beta + (\beta^2 - \alpha)^{0,5}$

with:

$\alpha = 0,0072\ (\ell_s □ D_2)^2 \cdot R'_e/235$

$\beta = 0,48 + 0,5\ \alpha + 0,1\ \alpha^{0,5}$

ℓ_s : Length, in mm, of the maximum unsupported reach of the cylinder rod.

2.2 Hydraulic systems

2.2.1 General

a) The design pressure for calculations to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure is to be at least 1,25 times the maximum working pressure to be expected under the operational conditions specified in [3], taking into account any pressure which may exist in the low pressure side of the system.

b) The power piping for hydraulic steering gear is to be arranged so that transfer between units can be readily effected.

c) Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

d) The hydraulic piping system, including joints, valves, flanges and other fittings, is to comply with the requirements of Ch 1, Sec 10 for class I piping systems and, in particular, with the requirements of Ch 1, Sec 9, [5], unless otherwise stated.

2.2.2 Materials

a) Ram cylinders, pressure housings of rotary vane type actuators, hydraulic power piping, valves, flanges and fittings are to be of steel or other approved ductile material.

b) In general, such material is to have an elongation of not less than 12% and a tensile strength not greater than 650 N/mm^2.

Grey cast iron may be accepted for valve bodies and redundant parts with low stress level, excluding cylinders, subject to special consideration.

2.2.3 Isolating valves

Shut-off valves, non-return valves or other appropriate devices are to be provided to:

- comply with the availability requirements of [3.4]
- keep the rudder steady in position in case of emergency.

2.2.4 Flexible hoses

Flexible hoses are to be in accordance with the provisions of Ch 1, Sec 4, [5.3].

2.2.5 Relief valves

a) Relief valves are to be fitted to any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces. The setting of the relief valves is not to exceed the design pressure. The valves are to be of adequate size and so arranged as to avoid an undue rise in pressure above the design pressure.

b) The setting pressure of the relief valves is not to be less than 1,25 times the maximum working pressure.

c) The minimum discharge capacity of the relief valve(s) is not to be less than the total capacity of the pumps which can deliver through it (them), increased by 10%. Under such conditions, the rise in pressure is not to exceed 10% of the setting pressure. In this respect, due consideration is to be given to the foreseen extreme ambient conditions in relation to oil viscosity.

2.2.6 Hydraulic oil reservoirs

Hydraulic power-operated steering gear is to be provided with the following:

- a low level alarm for each hydraulic fluid reservoir to give the earliest practicable indication of hydraulic fluid leakage. Audible and visual alarms are to be given on the navigation bridge and in the machinery space where they can be readily observed
- where the main steering gear is required to be power operated, a storage mean, as a readily accessible drum, having sufficient capacity to recharge at least one power actuating system if necessary.

2.2.7 Hydraulic pumps

Hydraulic pumps are to be type tested in accordance with the provisions of [7.1.1].

2.2.8 Filters

a) Hydraulic power-operated steering gear are to be provided with arrangements to maintain the cleanliness of the hydraulic fluid taking into consideration the type and design of the hydraulic system.

b) Filters of appropriate mesh fineness are to be provided in the piping system, in particular to ensure the protection of the pumps.

2.2.9 Hydraulic power supply

Hydraulic power installations supplying steering gear may also supply other equipment at the same time provided that:

a) the operation of the steering gear is not affected by the operation of this equipment

b) the piping system of this system can be isolated from the steering gear system by means of closing valves.

2.2.10 Accumulators

a) Accumulators, if fitted, are to be designed in accordance with Ch 1, Sec 9, [5.5.3].

b) The hydraulic side of the accumulators which can be isolated is to be provided with a relief valve or another device offering equivalent protection in case of overpressure.

2.2.11 Rudder actuators

a) rudder actuators are to be designed in accordance with the relevant requirements of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 3 for class 1 pressure vessels, considering also the following provisions

b) the permissible primary general membrane stress is not to exceed the lower of the following values:

$$\frac{R}{A} \quad \text{or} \quad \frac{R_e}{B}$$

where A and B are given in Tab 2.

c) oil seals between non-moving parts, forming part of the external pressure boundary, are to be of metal upon metal or equivalent type

d) oil seals between moving parts, forming part of the external pressure boundary, are to be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage may be accepted

e) the strength and connection of the cylinder heads (or, in the case of actuators of the rotary type, the fixed vanes) acting as rudder stops are to comply with the provisions of [6.3.1].

Table 2 : Coefficients A and B

Coefficient	Steel	Cast steel	Nodular cast iron
A	3,5	4	5
B	1,7	2	3

2.3 Electrical systems

2.3.1 Application

The provisions of [2.3.2] to [2.3.6] apply to all electric or electrohydraulic steering gear.

The provisions of [2.3.7] and [2.3.8] apply to steering gear where main and auxiliary steering are electric or electrohydraulic.

2.3.2 Power circuit supply

The circuits supplying electric or electrohydraulic steering gear are to have adequate rating for supplying all motors which can be simultaneously connected to them and may be required to operate simultaneously.

2.3.3 Motors and associated control gear

a) To determine the required characteristics of the electric motors for power units, the breakaway torque and maximum working torque of the steering gear under all operating conditions are to be considered. The ratio of pull-out torque to rated torque is to be at least 1,6.

b) Motors for steering gear power units may be rated for intermittent power demand.

   The rating is to be determined on the basis of the steering gear characteristics of the yacht in question; the rating is always to be, at least:

   - S3 - 40% for motors of electric steering gear power units
   - S6 - 25% for motors of electrohydraulic steering gear power units and for convertors.

c) Each electric motor of a main or auxiliary steering gear power unit is to be provided with its own separate motor starter gear, located within the steering gear compartment.

2.3.4 Supply of motor control circuits and steering gear control systems

a) Each control for starting and stopping of motors for power units is to be served by its own control circuits supplied from its respective power circuits.

b) Any electrical main and auxiliary steering gear control system operable from the navigating bridge is to be served by its own separate circuit supplied from a steering gear power circuit from a point within the steering gear compartment, or directly from switchboard busbars supplying that steering gear power circuit at a point on the switchboard adjacent to the supply to the steering gear power circuit. The power supply systems are to be protected selectively.

2.3.5 Circuit protection

a) Short-circuit protection is to be provided for each control circuit and each power circuit of electric or electrohydraulic main and auxiliary steering gear.

b) No protection other than short-circuit protection is to be provided for steering gear control system supply circuits.

c) Protection against excess current (e.g. by thermal relays), including starting current, if provided for power circuits, is to be for not less than twice the full load current of the motor or circuit so protected, and is to be arranged to permit the passage of the appropriate starting currents.

d) Steering gear motor circuits obtaining their power supply via an electronic converter, e.g. for speed control, and which are limited to full load current are exempt from the requirement to provide protection against excess current, including starting current, of not less than twice the full load current of the motor. The required overload alarm is to be set to a value not greater than the normal load of the electronic converter.

Note 1: "Normal load" is the load in normal mode of operation that approximates as close as possible to the most severe conditions of normal use in accordance with the manufacturer's operating instructions.

e) Where fuses are fitted, their current ratings are to be two step higher than the rated current of the motors. However, in the case of intermittent service motors, the fuse rating is not to exceed 160% of the rated motor current.

f) The instantaneous short-circuit trip of circuit breakers is to be set to a value not greater than 15 times the rated current of the drive motor.

g) The protection of control circuits is to correspond to at least twice the maximum rated current of the circuit, though not, if possible, below 6 A.

2.3.6 Starting and stopping of motors for steering gear power units

a) Motors for power units are to be capable of being started and stopped from a position on the navigation bridge and from a point within the steering gear compartment.

b) Means are to be provided at the position of motor starters for isolating any remote control starting and stopping devices (e.g. by removal of the fuse-links or switching off the automatic circuit breakers).

c) Main and auxiliary steering gear power units are to be arranged to restart automatically when power is restored after a power failure.

2.3.7 Power circuit supply in case of electric or electrohydraulic main and auxiliary steering gear

a) Electric or electrohydraulic steering gear is to be served by at least two exclusive circuits fed directly from the main switchboard; however one of the circuits may be supplied through the emergency switchboard.

b) Auxiliary electric or electrohydraulic steering gear, associated with main electric or electrohydraulic steering gear, may be connected to one of the circuits supplying the main steering gear.

2.3.8 Separation in case of electric or electrohydraulic main and auxiliary steering gear

a) Where duplicated electric power circuits or steering gear control system are provided, they are to be separated as far as practicable.

b) In the case of double follow-up control, the amplifier is to be designed and fed so as to be electrically and mechanically separated. In the case of non-follow-up control and follow-up control, it is to be ensured that the follow-up amplifier is protected selectively.

c) Control circuits for additional control systems, e.g. steering lever or autopilot, are to be designed for all-pole disconnection.

d) The feedback units and limit switches, if any, for the steering gear control systems are to be separated electrically and mechanically connected to the rudder stock or actuator separately.

2.4 Control, monitoring and alarm systems

2.4.1 Displays and alarms

Displays and alarms are to be provided in the locations indicated in Tab 3.

Table 3 : Location of displays and alarms

Item	Display	Alarms (audible and visible)	Location		
			Navigation Bridge **(1)**	Steering gear compartment	Steering gear compartment or engine room
Indication that electric motor of each power unit is running	X		X		X
Power failure of each power unit		X	G		X
Overload of electric motor of each power unit		X	G		X
Phase failure of electric motor of each power unit **(2)**		X	G		X
Low level of each hydraulic fluid reservoir		X	G		X
Hydraulic lock		X	G		X
Power failure of each control system		X	X		
Rudder angle indicator	X		X	X	

(1) G: Group alarm
(2) Where three-phase supply is used.

2.4.2 Rudder angle indication

The angular position of the rudder is to be indicated on the navigating bridge, if the main steering gear is power operated. The rudder angle indication is to be independent of the steering gear control system and be supplied through the emergency switchboard, or by an alternative and independent source of electrical power.

3 Design and construction

3.1 General provisions

3.1.1 Every yacht is to be provided with main steering gear and auxiliary steering gear to the satisfaction of the Society.

3.2 Strength, performance and power operation of the steering gear

3.2.1 Main steering gear

The main steering gear and rudder stock are to be:

a) capable of steering the yacht at maximum ahead service speed, which is to be demonstrated

b) capable of putting the rudder over from 35° on one side to 35° on the other side with the yacht at its deepest seagoing draught and running ahead at maximum ahead service speed and, under the same conditions, from 35° on either side to 30° on the other side in not more than 28 s

c) operated by power where necessary to fulfil the requirements of item b), and

d) so designed that they will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials at maximum astern speed and maximum rudder angle.

3.2.2 Auxiliary steering gear

The auxiliary steering gear is to be:

a) sufficient to steer the yacht at navigable speed

b) capable of putting the rudder over from 15° on one side to 15° on the other side in not more than 60s with the yacht at its deepest seagoing draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater, and

c) operated by power where necessary to meet the requirements of item b)

d) operational rapidly. If the operation of the auxiliary steering gear requires immobilisation of the tiller, an efficient braking system is to be installed.

   In case of hydraulic steering gear, braking may be obtained by shutting off the isolating valves, fitted directly on the actuator.

3.2.3 Hand operation

As a rule, operation of hand operated steering gears should not require an effort exceeding 160 N under normal conditions.

3.3 Control of the steering gear

3.3.1 Control of the main steering gear

Control of the main steering gear is to be provided on the navigation bridge.

3.3.2 Control of the auxiliary steering gear

Control of the auxiliary steering gear is to be provided on the navigation bridge, in the steering gear compartment or in another suitable position.

3.4 Arrangement of main and auxiliary steering gear

3.4.1 Availability

The main steering gear and the auxiliary steering gear are to be arranged so that failure of one of the following components will not render the other inoperative:

- for electric steering gear: electric motor
- for hydraulic steering gear: hydraulic pump or its prime mover
- for mechanical steering gear: mechanical components such as cables or chains but excluding the tiller.

3.5 Autopilot

3.5.1 An autopilot may be installed as a complement to main and auxiliary steering gear when it is possible to disconnect rapidly this autopilot. The main and auxiliary steering gear shall not be affected by the autopilot when disconnected.

3.5.2 If the autopilot is considered as an auxiliary steering gear as indicated in [1.3.2] then the autopilot shall be reviewed as such.

4 Design and construction - Requirements for yachts equipped with several rudders

4.1 Principle

4.1.1 General

In addition to the provisions of [2] and [3], as applicable, yachts equipped with two or more aft rudders are to comply with the provisions of the present Article.

4.1.2 Availability

Where the yacht is fitted with two or more rudders, each having its own actuation system, the latter need not be duplicated.

4.1.3 Equivalent rudder stock diameter

Where the rudders are served by a common actuating system, the diameter of the rudder stock referred to in [3.2.1] is to be replaced by the equivalent diameter d obtained from the following formula:

$$d = \sqrt[3]{\sum_j d_j^3}$$

with:

d_j : Rule diameter of the upper part of the rudder stock of each rudder in way of the tiller.

4.2 Synchronisation

4.2.1 General

Where the yacht has several rudders, a system for synchronising the movement of both rudders is to be fitted, either:

- by a mechanical coupling, or
- by other systems giving automatic synchronising adjustment.

4.2.2 Non-mechanical synchronisation

Where the synchronisation of the rudder motion is not achieved by a mechanical coupling, the following provisions are to be met:

a) the angular position of each rudder is to be indicated on the navigation bridge

b) the rudder angle indicators are to be independent from each other and, in particular, from the synchronising system

c) in case of failure of the synchronising system, means are to be provided for disconnecting this system so that steering capability can be maintained or rapidly regained.

5 Design and construction - Requirements for yachts equipped with thrusters as steering means

5.1 Principle

5.1.1 General

The main and auxiliary steering gear referred to in [3] may consist of thrusters of the following types:

- azimuth thrusters
- water-jets
- cycloidal propellers,

complying with the provisions of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 12, as far as applicable.

5.1.2 Actuation system

Thrusters used as steering means are to be fitted with a main actuation system and an auxiliary actuation system.

5.1.3 Control system

Where the steering means of the yacht consists of two or more thrusters, their control system is to include a device ensuring an automatic synchronisation of the thruster rotation, unless each thruster is so designed as to withstand any additional forces resulting from the thrust exerted by the other thrusters.

5.2 Use of azimuth thrusters

5.2.1 Azimuth thrusters used as sole steering means

Where the yacht is fitted with one azimuth thruster used as the sole steering means, this thruster is to comply with [3.3.1] or [3.2.1], as applicable, except that:

a) the main actuation system is required to be capable of a rotational speed of at least 0,4 rpm and to be operated by power where the expected steering torque exceeds 1,5 kN·m

b) the auxiliary actuation system is required to be capable of a rotational speed of at least 0,1 rpm and to be operated by power where the expected steering torque exceeds 3 kN·m.

5.2.2 Azimuth thrusters used as auxiliary steering gear

Where the auxiliary steering gear referred to in [3.3.1] or [3.1.1] consists of one or more azimuth thrusters, at least one such thruster is to capable of:

- steering the yacht at maximum ahead service speed
- being brought speedily into action in case of emergency
- a rotational speed of at least 0,4 rpm.

The auxiliary actuation system referred to in [5.1.2] need not be fitted.

5.2.3 Omission of the auxiliary actuation system

Where the steering means of the yacht consists of two independent azimuth thrusters or more, the auxiliary actuation system referred to in [5.1.2] need not be fitted provided that:

- the thrusters are so designed that the yacht can be steered with any one out of operation
- the actuation system of each thruster complies with [5.2.1], item b).

5.3 Use of water-jets

5.3.1 The use of water-jets as steering means are to be given special consideration by the Society.

6 Arrangement and installation

6.1 Steering gear room arrangement

6.1.1 The steering gear compartment is to be:

a) readily accessible and, as far as practicable, separated from machinery spaces, and

b) provided with suitable arrangements to ensure working access to steering gear machinery and controls. These arrangements are to include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

6.2 Rudder actuator installation

6.2.1 Rudder actuators are to be installed on foundations of strong construction so designed as to allow the transmission to the yacht structure of the forces resulting from the torque applied by the rudder and/or by the actuator, considering the strength criteria defined in [2.1.3] and [6.3.1]. The structure of the yacht in way of the foundations is to be suitably strengthened.

Where the rudder actuators are bolted to the hull, the grade of the bolts used is not to be less than 8.8. Unless the bolts are adjusted and fitted with a controlled tightening, strong shocks are to be fitted in order to prevent any lateral displacement of the rudder actuator.

The fixation of actuators on yacht's structure built in composite materials is to be designed to prevent their loss.

6.3 Overload protections

6.3.1 Mechanical rudder stops

a) The steering gear is to be provided with strong rudder stops capable of mechanically stopping the rotation of the rudder at an angle slightly greater than its maximum working angle. Alternatively, these stops may be fitted on the yacht to act on another point of the mechanical transmission system between the rudder actuator and the rudder blade. These stops may be built in with the actuator design.

b) The scantlings of the rudder stops and of the components transmitting to the yacht's structure the forces applied on these stops are to be determined in accordance with [2.1.3].

   As a general rule, the rudder stops are to be fitted between the rudder actuator and the rudder stock, unless the rudder stock as well as all the components transmitting mechanical forces between the rudder actuator and the rudder blade are suitably strengthened.

6.3.2 Rudder angle limiters

a) Power-operated steering gear is to be provided with positive arrangements, such as limit switches, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronised with the gear itself and not with the steering gear control.

b) For power-operated steering gears and where the rudder may be oriented to more than 35° at very reduced speed, it is recommended to fit a limit system 35° for full speed. A notice is to be displayed at all steering wheel stations indicating that rudder angles of more than 35° are to be used only at very reduced speed.

6.3.3 Relief valves

Relief valves are to be fitted in accordance with [2.2.5].

6.3.4 Buffers

Buffers are to be provided on all yachts fitted with mechanical steering gear. They may be omitted on hydraulic gear equipped with relief valves or with calibrated bypasses.

6.4 Means of communication

6.4.1 A means of communication is to be provided between the navigation bridge and the steering gear compartment.

When an emergency source of power is fitted, the means of communication is to be fed through the emergency switchboard.

6.5 Operating instructions

6.5.1 For steering gear comprising two identical power units intended for simultaneous operation, both normally provided with their own (partly or mutually) separate control systems, the following standard notice is either to be placed on a signboard fitted at a suitable place on the steering control post on the bridge or incorporated into the operation manual:

CAUTION

IN SOME CIRCUMSTANCES WHEN 2 POWER UNITS ARE RUNNING SIMULTANEOUSLY, THE RUDDER MAY NOT RESPOND TO THE HELM. IF THIS HAPPENS STOP EACH PUMP IN TURN UNTIL CONTROL IS REGAINED.

7 Certification, inspection and testing

7.1 Type tests of hydraulic pumps

7.1.1 Each type of power unit pump is to be subjected in the workshop to a type test of not less than 100 hours' duration.

The test arrangements are to be such that the pump may run both:

- in idling conditions, and
- at maximum delivery capacity at maximum working pressure.

During the test, idling periods are to be alternated with periods at maximum delivery capacity at maximum working pressure. The passage from one condition to another is to occur at least as quickly as on board.

During the test, no abnormal heating, excessive vibration or other irregularities are permitted.

After the test, the pump is to be disassembled and inspected.

Note 1: Type tests may be waived for a power unit which has been proven to be reliable in marine service.

7.2 Testing of materials

7.2.1 Components subject to pressure or transmitting mechanical forces

a) Materials of components subject to pressure or transmitting mechanical forces, specifically:
   - cylindrical shells of hydraulic cylinders, rams and piston rods
   - tillers, quadrants
   - rotors and rotor housings for rotary vane steering gear
   - hydraulic pump casings, and
   - hydraulic accumulators, if any,

   are to be duly tested, including examination for internal defects, in accordance with the requirements of NR216 Materials and Welding.

b) A works' certificate may be accepted for low stressed parts, provided that all characteristics for which verification is required are guaranteed by such certificate.

7.2.2 Hydraulic piping, valves and accessories

Tests for materials of hydraulic piping, valves and accessories are to comply with the provisions of Ch 1, Sec 4, [6.3].

7.3 Inspection and tests during manufacturing

7.3.1 Components subject to pressure or transmitting mechanical forces

The mechanical components referred to in [7.2.1] are to be subjected to appropriate non-destructive tests. For hydraulic cylinder shells, pump casings and accumulators, refer to NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 3.

Defects may be repaired by welding only on forged parts or steel castings of weldable quality. Such repairs are to be conducted under the supervision of the Surveyor in accordance with the applicable requirements of NR216 Materials and Welding.

7.3.2 Hydraulic piping, valves and accessories

Hydraulic piping, valves and accessories are to be inspected and tested during manufacturing in accordance with Ch 1, Sec 4, [6], for a class I piping system.

7.4 Inspection and tests after completion

7.4.1 Hydrostatic tests

Hydraulic cylinder shells and accumulators are to be subjected to hydrostatic tests according to the relevant provisions of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 3.

Hydraulic piping, valves and accessories and hydraulic pumps are to be subjected to hydrostatic tests according to the relevant provisions of Ch 1, Sec 4, [6.4].

7.4.2 Shipboard tests

After installation on board the yacht, the steering gear is to be subjected to the tests detailed in Ch 1, Sec 10, [3.8].

7.4.3 Sea trials

For the requirements of sea trials, refer to Ch 1, Sec 10.

Section 4 Arrangement and Installation of Piping Systems

1 General

1.1 Application

1.1.1 Specific requirements

Specific requirements for yacht piping systems and machinery piping systems are given in Ch 1, Sec 5 to Ch 1, Sec 9.

1.2 Documentation to be submitted

1.2.1 Documents

The documents listed in Tab 1 are to be submitted.

1.2.2 Additional information

The information listed in Tab 2 is also to be submitted.

Table 1 : Documents to be submitted

No.	Document **(1)**
1	Drawing showing the arrangement of the sea chests and yacht side valves
2	Diagram of the bilge (and ballast) systems (in and outside machinery spaces)
3	Diagram of the scuppers and sanitary discharge systems
4	Diagram of the air, sounding and overflow systems
5	Diagram of cooling systems (sea water and fresh water)
6	Diagram of fuel oil system
7	Drawings of the fuel oil tanks not forming part of the yacht's structure
8	Diagram of the lubricating oil system
9	Diagram of the hydraulic systems intended for essential services or located in machinery spaces
10	Diagram of the compressed air system
11	Diagram of the hydraulic and pneumatic remote control systems
12	Diagram of the remote level gauging system
13	Diagram of the exhaust gas system
14	Diagram of drip trays and gutterway draining system
15	Arrangement of the ventilation system
16	Drawings and specification of valves and accessories, where required in [5.4]
(1)	Diagrams are also to include, where applicable, the (local and remote) control and monitoring systems and automation systems.

Table 2 : Information to be submitted

No.	Document
1	Nature, service temperature and pressure of the fluids
2	Material, external diameter and wall thickness of the pipes
3	Type of the connections between pipe lengths, including details of the weldings, where provided
4	Material, type and size of the accessories
5	Capacity, prime mover and, when requested, location of the pumps
6	Type approval certificate of plastic pipes.

1.3 Definitions

1.3.1 Piping and piping systems

a) Piping includes pipes and their connections, flexible hoses and expansion joints, valves and their actuating systems, other accessories (filters, level gauges, etc.) and pump casings.

b) Piping systems include piping and all the interfacing equipment such as tanks, pressure vessels, heat exchangers, pumps and centrifugal purifiers, but do not include boilers, turbines, internal combustion engines and reduction gears.

Note 1: The equipment other than piping is to be designed in accordance with the relevant Sections of Part C, Chapter 1.

1.3.2 Design pressure

a) The design pressure of a piping system is the pressure considered by the manufacturer to determine the scantling of the system components. It is not to be taken less than the maximum working pressure expected in this system or the highest setting pressure of any safety valve or relief device, whichever is the greater.

b) The design pressure of steam piping located upstream of pressure reducing valves (high pressure side) is not to be less than the setting pressure of the boiler or superheater safety valves.

c) The design pressure of a piping system located on the low pressure side of a pressure reducing valve where no safety valve is provided is not to be less than the maximum pressure on the high pressure side of the pressure reducing valve.

d) The design pressure of a piping system located on the delivery side of a pump or a compressor is not to be less than the setting pressure of the safety valve for displacement pumps or the maximum pressure resulting from the operating (head-capacity) curve for centrifugal pumps, whichever is the greater.

1.3.3 Design temperature

The design temperature of a piping system is the maximum temperature of the medium inside the system.

1.3.4 Flammable oils

Flammable oils include fuel oils, lubricating oils, thermal oils and hydraulic oils.

1.4 Symbols and units

1.4.1 The following symbols and related units are commonly used in this Section. Additional symbols, related to some formulae indicated in this Section, are listed wherever it is necessary.

p : Design pressure, in MPa

T : Design temperature, in °C

t : Rule required minimum thickness, in mm

D : Pipe external diameter, in mm.

1.5 Class of piping systems

1.5.1 Purpose of the classes of piping systems

Piping systems are subdivided into three classes, denoted as class I, class II and class III, for the purpose of acceptance of materials, selection of joints, heat treatment, welding, pressure testing and the certification of fittings.

1.5.2 Definitions of the classes of piping systems

Classes I, II and III are defined in Tab 3.

1.6 Materials

1.6.1 General

Materials to be used in piping systems are to be suitable for the medium and the service for which the piping is intended.

1.6.2 Use of metallic materials

a) Materials for class I and class II piping systems are to be manufactured and tested in accordance with the appropriate requirements of NR216 Materials and Welding.

b) Materials for class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable national or international standards or specifications.

c) Mechanical characteristics required for metallic materials are specified in NR216 Materials and Welding.

1.6.3 Use of plastics

a) Plastics may be used for piping systems belonging to class III in accordance with [3]. The use of plastics for other systems or in other conditions will be given special consideration.

b) Plastics intended for piping systems dealt with in this Section are to be of a type approved by the Society.

Table 3 : Class of piping systems

Media conveyed by the piping system	Class I	Class II **(1) (2)**	Class III **(3)**
Flammable media: • heated above flashpoint, or • having flashpoint < 60°C	without special safeguards **(4)**	with special safeguards **(4)**	not applicable
Fuel oil **(5)** Lubricating oil Flammable hydraulic oil **(6)**	$p > 1,6$ or $T > 150$	other **(7)**	$p \le 0,7$ and $T \le 60$
Other media **(6) (8)**	$p > 4$ or $T > 300$	other **(7)**	$p \le 1,6$ and $T \le 200$

(1) Valves under static pressure on oil fuel tanks or lubricating oil tanks belong to class II.
(2) Valves and fittings fitted on the yacht side and collision bulkhead belong to class II. See also [6.4.3] b).
(3) The open ended pipes, irrespective of T, generally belong to class III (as drains, overflows, vents, exhaust gas lines, boiler escape pipes, etc.).
(4) Safeguards for reducing leakage possibility and limiting its consequences:
e.g. pipes led in positions where leakage of internal fluids will not cause a potential hazard or damage to surrounding areas which may include the use of pipe ducts, shielding, screening etc.
(5) Design pressure for fuel oil systems is to be determined in accordance with Tab 4.
(6) Steering gear hydraulic piping system belongs to class I irrespective of p and T.
(7) Pressure and temperature conditions other than those required for class I and class III.
(8) Including water, air, gases, non-flammable hydraulic oil.
Note 1: p : Design pressure, as defined in [1.3.2], in MPa.
Note 2: T : Design temperature, as defined in [1.3.3], in °C.
Note 3: Flammable media generally include the flammable liquids as oil fuel, lubricating oil and flammable hydraulic oil.

Table 4 : Definition of the design pressure for fuel oil systems

Working pressure P, in MPa	Working temperature T, in °C	
	$T \le 60$	$T > 60$
$P \le 0,7$	0,3 MPa or P max., whichever is the greater	0,3 MPa or P max., whichever is the greater
$P > 0,7$	P max.	1,4 MPa or P max., whichever is the greater

1.6.4 Use of flexible piping

a) Flexible piping may be used for yachts with a length of less than 24 m and for piping systems belonging to class III.
The use of flexible piping for other systems or in other conditions will be given special consideration.
Exceptional use of flexible piping for yachts of 24 m in length and more will be given special consideration.

b) Flexible piping is to be in accordance with [4].

1.6.5 Conditions of use

Conditions of uses of materials used in piping systems are to be in accordance with the provisions of Tab 5.

2 Design of metallic piping systems

2.1 General

2.1.1 Conditions of use

Materials used in metallic piping systems are to be in accordance with the provisions of Tab 5.

2.2 Thickness of pressure piping

2.2.1 Calculation of the thickness of pressure pipes

a) The thickness t, in mm, of pressure pipes is to be determined by the following formula but, in any case, is not to be less than the minimum thickness given in Tab 7 to Tab 10:

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}}$$

where:

t_0 : Coefficient, in mm, equal to:

$$t_0 = \frac{p \cdot D}{2Ke + p}$$

p and D : As defined in [1.4.1]

K : Permissible stress defined in [2.2.2]

e : Weld efficiency factor to be:

- equal to 1 for seamless pipes and pipes fabricated according to a welding procedure approved by the Society
- specially considered by the Society for other welded pipes, depending on the service and the manufacture procedure

b : Thickness reduction due to bending defined in [2.2.3], in mm

c : Corrosion allowance defined in [2.2.4], in mm

a : Negative manufacturing tolerance percentage:

- equal to 10 for copper and copper alloy pipes, cold drawn seamless steel pipes and steel pipes fabricated according to a welding procedure approved by the Society
- equal to 12,5 for hot laminated seamless steel pipes
- subject to special consideration by the Society in other cases.

b) The thickness thus determined does not take into account the particular loads to which pipes may be subjected. Attention is to be drawn in particular to the case of high temperature and low temperature pipes.

Table 5 : Conditions of use of materials in piping systems

Material	Allowable classes	Maximum design temperature **(1)**	Particular conditions of use
Carbon and carbon-manganese steels	III, II, I	400 **(2)**	Class I and II pipes are to be seamless drawn pipes **(3)**
Copper and aluminium brass	III, II, I	200	• Not to be used in fuel oil systems, except for class III pipes of a diameter not exceeding 25 mm not passing through fuel oil tanks • Pipes made of copper and copper alloys are to be seamless
Copper-nickel	III, II, I	300	
Special high temperature resistant bronze	III, II, I	260	
Stainless steel	III, II, I	300	Austenitic stainless steel is not to be used for sea water systems
Spheroidal graphite cast iron	III, II **(4)**	350	• Minimum elongation is not to be less than 12% on a gauge length of $5{,}65 \cdot S^{0{,}5}$, where S is the actual cross-sectional area of the test piece • Not to be used for boiler blow-down valves and pieces for connection to the shell plating
Grey cast iron	III, II **(5)**	220	Grey cast iron is not to be used for the following systems: • piping systems subject to shocks, high stresses and vibrations • bilge lines in tanks • parts of scuppers and sanitary discharge systems located next to the hull below the freeboard deck • hull valves and fittings • valves fitted on the collision bulkhead • valves fitted to fuel oil and lubricating oil tanks under static pressure head • class II fuel oil systems
Aluminium and aluminium alloys	III, II	200	See Tab 6
Plastics	III	See [3.3.4]	See Tab 6

(1) Maximum design temperature is not to exceed that assigned to the class of piping

(2) Higher temperatures may be accepted if metallurgical behaviour and time dependent strength (ultimate tensile strength after 100 000 hours) are in accordance with national or international standards or specifications and if such values are guaranteed by the steel manufacturer

(3) Pipes fabricated by a welding procedure approved by the Society may also be used

(4) Use of spheroidal cast iron for class I piping systems will be given special consideration by the Society

(5) Use of grey cast iron is not allowed when the design pressure exceeds 1,3 MPa

Table 6 : Particular conditions of use for aluminium and aluminium alloys and plastics

L < 24 m	L > 24 m GT < 500	GT ≥ 500 or **charter yacht** carrying more than 12 passengers
Aluminium and aluminium alloys are not to be used in the following systems: • piping used for flammable oil in spaces with high fire risk and in all accommodation and service spaces (this includes air, sounding, and overflow pipes)	Aluminium and aluminium alloys are not to be used in the following systems **(3)**: • piping for fire water supply system **(1)** • piping leading to the hull with overboard connection under freeboard deck in spaces with high fire risk unless one of the following conditions is fulfilled **(2)**: - vertical position of hull connection more than 600 mm above the deepest waterline - closing valve remotely controlled from outside the considered space which isolates the aluminium part in order to protect against intake of seawater through damaged aluminium pipe - non return valve which isolates the aluminium part in order to protect against intake of seawater through damaged aluminium pipe - the pipe is permanently filled with seawater • piping used for flammable oil in spaces with high fire risk and in all accommodation and service spaces (this includes air, sounding, and overflow pipes)	The provisions of NR467 Rules for Steel Ships, Pt C, Sec 10, [2.1.2] apply
Plastics are not to be used in the following systems: • piping used for flammable oil in spaces with high fire risk and in all accommodation and service spaces (this includes air, sounding, and overflow pipes)	Plastics are not to be used in the following systems **(4)**: • piping for fire water supply system **(1)** • piping leading to the hull with overboard connection under freeboard deck in spaces with high fire risk unless one of the following conditions is fulfilled **(2)**: - vertical position of hull connection more than 600 mm above the deepest waterline - closing valve remotely controlled from outside the considered space which isolates the plastic part in order to protect against intake of seawater through damaged plastic pipe - non return valve which isolates the aluminium part in order to protect against intake of seawater through damaged plastic pipe - the pipe is permanently filled with seawater and certified L3 as per IMO Res. A753(18) • piping used for flammable oil in spaces with high fire risk and in all accommodation and service spaces (this includes air, sounding, and overflow pipes)	The provisions of NR467 Rules for Steel Ships, Pt C, Ch 1, App 3 apply

(1) This restriction could be waived if the arrangement allows to produce at least one powerful jet with the portable pump or the independently driven power pump as per Ch 4, Sec 5, [2.2.4].
(2) In all conditions, in case of machinery space of cat A, a fixed fire-extinguishing system is to be installed.
(3) As an alternative, piping could be insulated equivalent to steel.
(4) As an alternative, piping could be certified L1 or L2 as per IMO Res. A753(18) or insulated equivalent to steel.

Note 1: For the purpose of this Table, spaces of high fire risk refer to machinery spaces of category A as defined in Ch 4, Sec 1, [3.4.15] and galleys as defined in Ch 4, Sec 1, [3.4.12]

Note 2: Alternative design could be accepted in case of submission of a detailed risk assessment taking into account fire and flooding aspects. Reference is made to MSC.1 Circ 1212.

Table 7 : Minimum wall thickness for steel pipes

External diameter, in mm	Minimum nominal wall thickness, in mm			Minimum reinforced wall thickness, in mm **(4)**	Minimum extra-reinforced wall thickness, in mm **(5)**
	Pipes in general **(1)**	Vent, overflow and sounding pipes for integral tanks **(1) (2)**	Sea water pipes, bilge and ballast systems **(1) (3)**		
10,2 - 12,0	1,6	–	–	–	–
13,5 - 19,3	1,8	–	–	–	–
20,0	2,0	–	–	–	–
21,3 - 25,0	2,0	–	3,2	–	–
26,9 - 33,7	2,0	–	3,2	–	–
38,0 - 44,5	2,0	4,5	3,6	6,3	7,6
48,3	2,3	4,5	3,6	6,3	7,6
51,0 - 63,5	2,3	4,5	4,0	6,3	7,6
70,0	2,6	4,5	4,0	6,3	7,6
76,1 - 82,5	2,6	4,5	4,5	6,3	7,6
88,9 - 108,0	2,9	4,5	4,5	7,1	7,8
114,3 - 127,0	3,2	4,5	4,5	8,0	8,8
133,0 - 139,7	3,6	4,5	4,5	8,0	9,5
152,4 - 168,3	4,0	4,5	4,5	8,8	11,0
177,8	4,5	5,0	5,0	8,8	12,7
197,7	4,5	5,4	5,4	8,8	12,7
219,1	4,5	5,9	5,9	8,8	12,7
244,5 - 273,0	5,0	6,3	6,3	8,8	12,7
298,5 - 368,0	5,6	6,3	6,3	8,8	12,7
406,4 - 457,2	6,3	6,3	6,3	8,8	12,7

(1) Attention is drawn to the special requirements regarding:
- bilge and ballast systems
- scupper and discharge pipes
- sounding, air and overflow pipes
- ventilation systems
- CO_2 fire-extinguishing systems (see Part C, Chapter 4).

(2) For sounding pipes, the minimum wall thickness is intended to apply only to the part outside the tank

(3) The minimum wall thickness for bilge lines and ballast lines through deep tanks is to be subject to special consideration by the Society

(4) Reinforced wall thickness applies to pipes passing through tanks containing a fluid distinct from that conveyed by the pipe as well as for exposed parts of air pipes

(5) Extra-reinforced wall thickness applies to pipes connected to the shell

Note 1: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards

Note 2: For pipes efficiently protected against corrosion, the thickness may be reduced by an amount up to 1 mm

Note 3: The thickness of threaded pipes is to be measured at the bottom of the thread

Note 4: The minimum thickness listed in this table is the nominal wall thickness and no allowance is required for negative tolerance and reduction in thickness due to bending

Note 5: Exhaust gas pipe minimum wall thickness is to be subject to special consideration by the Society

Table 8 : Minimum wall thickness for copper and copper alloy pipes

External diameter, in mm	Minimum wall thickness, in mm	
	Copper	Copper alloy
8 - 10	1,0	0,8
12 - 20	1,2	1,0
25 - 44,5	1,5	1,2
50 - 76,1	2,0	1,5
88,9 - 108	2,5	2,0
133 - 159	3,0	2,5
193,7 - 267	3,5	3,0
273-457,2	4,0	3,5
470	4,0	3,5
508	4,5	4,0

Note 1: The indicated values are valid for pipes in general, sea water pipes and vent, overflow and sounding pipes. When reinforced or extra-reinforced wall thicknesses are required, the values of the respectively one and two lines below are to be considered
Note 2: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards

Table 9 : Minimum wall thickness for austenitic stainless steel pipes

External diameter, in mm	Minimum wall thickness, in mm
10,2 - 17,2	1,0
21,3 - 48,3	1,6
60,3 - 88,9	2,0
114,3 - 168,3	2,3
219,1	2,6
273,0	2,9
323,9 - 406,4	3,6
over 406,4	4,0

Note 1: The indicated values are valid for pipes in general, sea water pipes and vent, overflow and sounding pipes. When reinforced or extra-reinforced wall thicknesses are required, the values of the respectively one and two lines below are to be considered
Note 2: Diameters and thicknesses according to national or international standards may be accepted

Table 10 : Minimum wall thickness for aluminium and aluminium alloy pipes

External diameter, in mm	Minimum wall thickness, in mm
0 - 10	1,5
12 - 38	2,0
43 - 57	2,5
76 - 89	3,0
108 - 133	4,0
159 - 194	4,5
219 - 273	5,0
above 273	5,5

Note 1: The indicated values are valid for pipes in general, sea water pipes and vent, overflow and sounding pipes. When reinforced or extra-reinforced wall thicknesses are required, the values of the respectively one and two lines below are to be considered
Note 2: A different thickness may be considered by the Society on a case by case basis, provided that it complies with recognised standards

2.2.2 Permissible stress

a) The permissible stress K is given in:
   - Tab 11 for carbon and carbon-manganese steel pipes
   - Tab 12 for alloy steel pipes, and
   - Tab 13 for copper and copper alloy pipes,

   as a function of the temperature. Intermediate values may be obtained by interpolation.

b) Where, for carbon steel and alloy steel pipes, the value of the permissible stress K is not given in Tab 11 or Tab 12, it is to be taken equal to the lowest of the following values:

$$\frac{R_{m,20}}{2,7} \qquad \frac{R_e}{A} \qquad \frac{S_R}{A} \qquad S$$

where:

$R_{m,20}$: Minimum tensile strength of the material at ambient temperature (20°C), in N/mm^2

R_e : Minimum yield strength or 0,2% proof stress at the design temperature, in N/mm^2

S_R : Average stress to produce rupture in 100000 h at design temperature, in N/mm^2

S : Average stress to produce 1% creep in 100000 h at design temperature, in N/mm^2

A : Safety factor to be taken equal to:

- 1,6 when R_e and S_R values result from tests attended by the Society
- 1,8 otherwise.

c) The permissible stress values adopted for materials other than carbon steel, alloy steel, copper and copper alloy is to be specially considered by the Society.

2.2.3 Thickness reduction due to bending

a) Unless otherwise justified, the thickness reduction b due to bending is to be determined by the following formula:

$$b = \frac{Dt_0}{2,5\rho}$$

where:

ρ : Bending radius measured on the centre line of the pipe, in mm

D : As defined in [1.4.1]

t_0 : As defined in [2.2.1].

b) When the bending radius is not given, the thickness reduction is to be taken equal to t_0 / 10

c) For straight pipes, the thickness reduction is to be taken equal to 0.

Table 11 : Permissible stresses for carbon and carbon-manganese steel pipes

Specified minimum tensile strength, in N/mm^2	Design temperature, in °C			
	≤50	100	150	200
320	107	105	99	92
360	120	117	110	103
410	136	131	124	117
460	151	146	139	132
490	160	156	148	141

Table 12 : Permissible stresses for alloy steel pipes

Type of steel	Specified minimum tensile strength, in N/mm^2	Design temperature, in °C		
		≤ 50	100	200
1 Cr1/2 Mo	440	159	150	137
2 1/4 Cr1 Mo annealed	410	76	67	57
2 1/4 Cr1 Mo normalised and tempered below 750 °C	490	167	163	153
2 1/4 Cr1 Mo normalised and tempered above 750 °C	490	167	163	153
1/2 Cr 1/2 Mo 1/4 V	460	166	162	147

Table 13 : Permissible stresses for copper and copper alloy pipes

Material (annealed)	Specified minimum tensile strength, in N/mm^2	Design temperature, in °C						
		≤ 50	75	100	125	150	175	200
Copper	215	41	41	40	40	34	27,5	18,5
Aluminium brass	325	78	78	78	78	78	51	24,5
Copper-nickel 95/5 and 90/10	275	68	68	67	65,5	64	62	59
Copper-nickel 70/30	365	81	79	77	75	73	71	69

Table 14 : Corrosion allowance for steel pipes

Piping system	Corrosion allowance, in mm
Compressed air	1,0
Hydraulic oil	0,3
Lubricating oil	0,3
Fuel oil	1,0
Fresh water	0,8
Sea water	3,0
Note 1: For pipes passing through tanks, an additional corrosion allowance is to be considered in order to account for the external corrosion. **Note 2:** The corrosion allowance of pipes efficiently protected against corrosion may be reduced by no more than 50%. **Note 3:** When the corrosion resistance of alloy steels is adequately demonstrated, the corrosion allowance may be disregarded.	

Table 15 : Corrosion allowance for non-ferrous metal pipes

Piping material **(1)**	Corrosion allowance, in mm **(2)**
Copper	0,8
Brass	0,8
Copper-tin alloys	0,8
Copper-nickel alloys with less than 10% of Ni	0,8
Copper-nickel alloys with at least 10% of Ni	0,5
Aluminium and aluminium alloys	0,5
(1) The corrosion allowance for other materials is to be specially considered by the Society. Where their resistance to corrosion is adequately demonstrated, the corrosion allowance may be disregarded. **(2)** In cases of media with high corrosive action, a higher corrosion allowance may be required by the Society.	

2.2.4 Corrosion allowance

The values of corrosion allowance c are given for steel pipes in Tab 14 and for non-ferrous metallic pipes in Tab 15.

2.2.5 Tees

As well as complying with the provisions of [2.2.1] to [2.2.4], the thickness t_T of pipes on which a branch is welded to form a Tee is not to be less than that given by the following formula:

$$t_T = \left(1 + \frac{D_1}{D}\right) \cdot t_0$$

where:

D_1 : External diameter of the branch pipe

D : As defined in [1.4.1]

t_0 : As defined in [2.2.1].

Note 1: This requirement may be dispensed with for Tees provided with a reinforcement or extruded.

2.3 Junction of metallic pipes

2.3.1 General

a) The junctions between metallic pipe lengths or between metallic pipe lengths and fittings are to be made by:
   - direct welding (butt-weld, socket-weld)
   - bolted flanges (welded-on or screwed-on)
   - threaded sleeve joints, or
   - mechanical joints (see [2.3.5]).

   The joints are to comply with a recognised standard or to be of a design proven to be suitable for the intended purpose and acceptable to the Society (see also [2.4.1]).

   The expression “mechanical joints” means devices intended for direct connection of pipe lengths other than by welding, flanges or threaded joints described in [2.3.2], [2.3.3] or [2.3.4].

b) The number of joints in flammable oil piping systems is to be kept to the minimum necessary for mounting and dismantling purposes.

c) The gaskets and packings used for the joints are to suit the design pressure, the design temperature and the nature of the fluids conveyed.

d) The junction between plastic pipes is to comply with [3].

e) For yachts of less than 500 GT, at the discretion of the Society, deviations of this requirement could be accepted if duly justified and documented.

2.3.2 Welded metallic joints

a) Welded joints are to be used in accordance with Tab 16. Welding and non destructive testing of welds are to be carried out in accordance with [2.4.1].

b) Butt-welded joints are to be of full penetration type, with or without special provision for a high quality of root side.

The expression "special provision for a high quality of root side" means that butt welds were accomplished as double welded or by use of a backing ring or inert gas back-up on first pass, or other similar methods accepted by the Society.

c) Slip-on sleeve and socket welded joints are to have sleeves, sockets and weldments of adequate dimensions in compliance with a standard recognised by the Society.

2.3.3 Metallic flange connections

a) In general, the metallic flange connections used for piping systems are to be in compliance with a standard recognised by the Society.

b) The material used for flanges and gaskets is to be suitable for the nature and temperature of the fluid, as well as pipes on which the flanges are to be fitted.

c) The dimensions and configuration of flanges and bolts are to be chosen in accordance with recognised standard intended for design pressure and design temperature of the piping system. Otherwise, the flange connections are subject to special consideration.

d) Flanges are to be attached to the pipes by welding or screwing. Examples of acceptable metallic flange connections are shown in Fig 1. However, other types of flange connections may be also considered by the Society in each particular case, provided that they are in accordance with national or international standards applicable to the piping system and recognise the boundary fluids, design pressure and temperature conditions, external or cyclic loading and location.

e) Permitted applications are indicated in Tab 17.

Table 16 : Use of welded and threaded metallic joints in piping systems

Joints	Permitted classes of piping	Restrictions of use
Butt-welded, with special provision for a high quality of root side **(1)**	III, II, I	no restrictions
Butt-welded, without special provision for a high quality of root side **(1)**	III, II	no restrictions
Slip-on sleeve and socket welded **(2)**	III	no restrictions
Threaded sleeve joints with tapered thread **(3)**	I	not allowed for: • pipes with outside diameter of more than 33,7 mm • pipes inside tanks • piping systems conveying flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur
	III, II	not allowed for: • pipes with outside diameter of more than 60,3 mm • pipes inside tanks • piping systems conveying flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur
Threaded sleeve joints with parallel thread **(3)**	III	not allowed for: • pipes with outside diameter of more than 60,3 mm • pipes inside tanks • piping systems conveying flammable media or services where fatigue, severe erosion or crevice corrosion is expected to occur

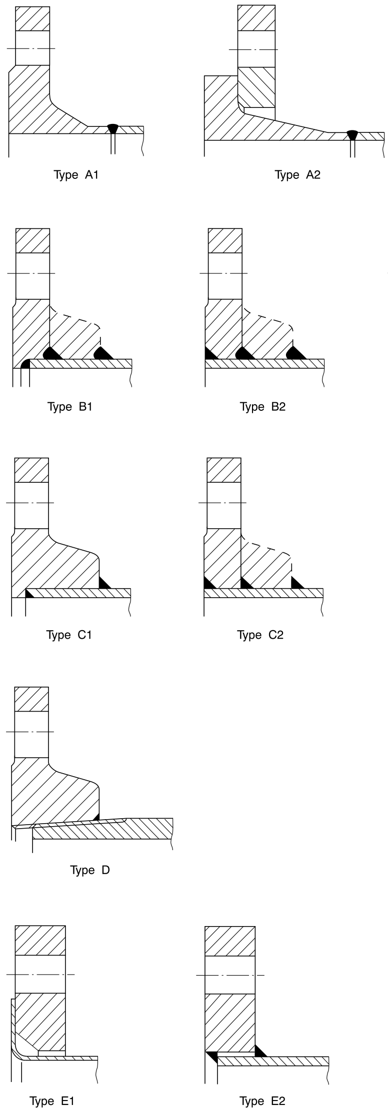
(1) For expression “special provision for a high quality of root side” see [2.3.2] b).
(2) Particular cases may be allowed by the Society for piping systems of Class I and II having outside diameter ≤ 88,9 mm except for piping systems conveying toxic media or services where fatigue, severe erosion or crevice corrosion is expected to occur.
(3) In particular cases, sizes in excess of those mentioned above may be accepted by the Society if found in compliance with a recognised national and/or international standard.
Note 1: Other applications are to be specially considered by the Society.

Table 17 : Use of metallic flange connections in piping systems (types as shown in Fig 1)

Type of media conveyed	Class of piping (see Tab 3)		
	I	II	III
Flammable liquids (where heated above flashpoint or having flashpoint < 60°C	A1, A2, B1, B2, B3 **(1) (2)**	A1, A2, B1, B2, B3, C1, C2, C3 **(1)**	not applicable
Fuel oil Lubricating oil	A1, A2, B1, B2, B3	A1, A2, B1, B2, B3, C1, C2, C3, E2 **(3)**	A1, A2, B1, B2, B3, C1, C2, C3, E2
Other media as water, air, gases (refrigerants), non-flammable hydraulic oil, etc.	A1, A2, B1, B2, B3 **(4)**	A1, A2, B1, B2, B3, C1, C2, C3, D, E2 **(3)**	A1, A2, B1, B2, B3, C1, C2, C3, D, E1, E2 **(3) (5) (6)**

(1) When design pressure p (see [1.3.2]) exceeds 1 MPa, types A1 and A2 only.
(2) For nominal diameter ND ≥ 150 mm, types A1 and A2 only.
(3) Type E2 only, for design pressure p ≤ 1,6 Mpa and design temperature T ≤ 150°C.
(4) When design temperature T (see [1.3.3] exceeds 400°C, types A1 and A2 only.
(5) Types D and E1 only, for design temperature T ≤ 250°C.
(6) Type E1 only, for water pipelines and for open ended lines (e.g. drain, overflow, air vent piping, etc.).

Figure 1 : Examples of metallic flange connections



Note 1: For type D, the pipe and flange are to be screwed with a tapered thread and the diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of the unthreaded pipe. For certain types of thread, after the flange has been screwed hard home, the pipe is to be expanded into the flange.

Note 2: The leg length of the fillet weld, as well as the dimension of the groove penetration in the flange, is to be in general equal to 1,5 times the pipe thickness but not less than 5 mm.

2.3.4 Slip-on threaded joints

a) Slip-on threaded joints having pipe threads where pressure-tight joints are made on the threads with parallel or tapered threads are to comply with requirements of a recognised national or international standard and are to be acceptable to the Society.

b) Slip-on threaded joints may be used for piping systems in accordance with Tab 16.

c) Threaded joints may be accepted also in CO_2 piping systems, provided that they are used only inside protected spaces and in CO_2 cylinder rooms.

2.3.5 Mechanical joints

Due to the great variations in design and configuration of mechanical joints, specific recommendation regarding calculation method for theoretical strength calculations is not specified. The Type Approval is to be based on the results of testing of the actual joints.

Below specified requirements are applicable to pipe unions, compression couplings, slip-on joints as shown in Fig 2. Similar joints complying with these requirements may be acceptable.

a) Mechanical joints including pipe unions, compression couplings, slip-on joints and similar joints are to be of approved type for the service conditions and the intended application.

b) Where the application of mechanical joints results in reduction in pipe wall thickness due to the use of bite type rings or other structural elements, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand the design pressure.

c) Construction of mechanical joints is to prevent the possibility of tightness failure affected by pressure pulsation, piping vibration, temperature variation and other similar adverse effects occurring during operation on board.

d) Material of mechanical joints is to be compatible with the piping material and internal and external media.

e) As far as applicable, the mechanical joints are to be tested to a burst pressure of 4 times the design pressure. For design pressures above 200 bar the required burst pressure is to be specially considered by the Society.

f) In general, mechanical joints are to be of fire resistant type as required by Tab 18.

g) Mechanical joints, which in the event of damage could cause fire or flooding, are not to be used in piping sections directly connected to the shell openings or tanks containing flammable fluids.

h) The mechanical joints are to be designed to withstand internal and external pressure as applicable and, where used in suction lines, are to be capable of operating under vacuum.

i) The number of mechanical joints in flammable liquid systems is to be kept to a minimum. In general, flanged joints conforming to recognised standards are to be used.

j) Piping in which a mechanical joint is fitted is to be adequately adjusted, aligned and supported. Supports or hangers are not to be used to force alignment of piping at the point of connection.

k) Slip-on joints are not to be used in pipelines in cargo holds, tanks, and other spaces which are not easily accessible, unless approved by the Society. Application of these joints inside tanks may be permitted only for the same media that is in the tanks. Unrestrained slip-on joints are to be used only in cases where compensation of lateral pipe deformation is necessary. Usage of these joints as the main means of pipe connection is not permitted.

l) Application of mechanical joints and their acceptable use for each service is indicated in Tab 18; dependence upon the class of piping, pipe dimensions, working pressure and temperature is indicated in Tab 19.

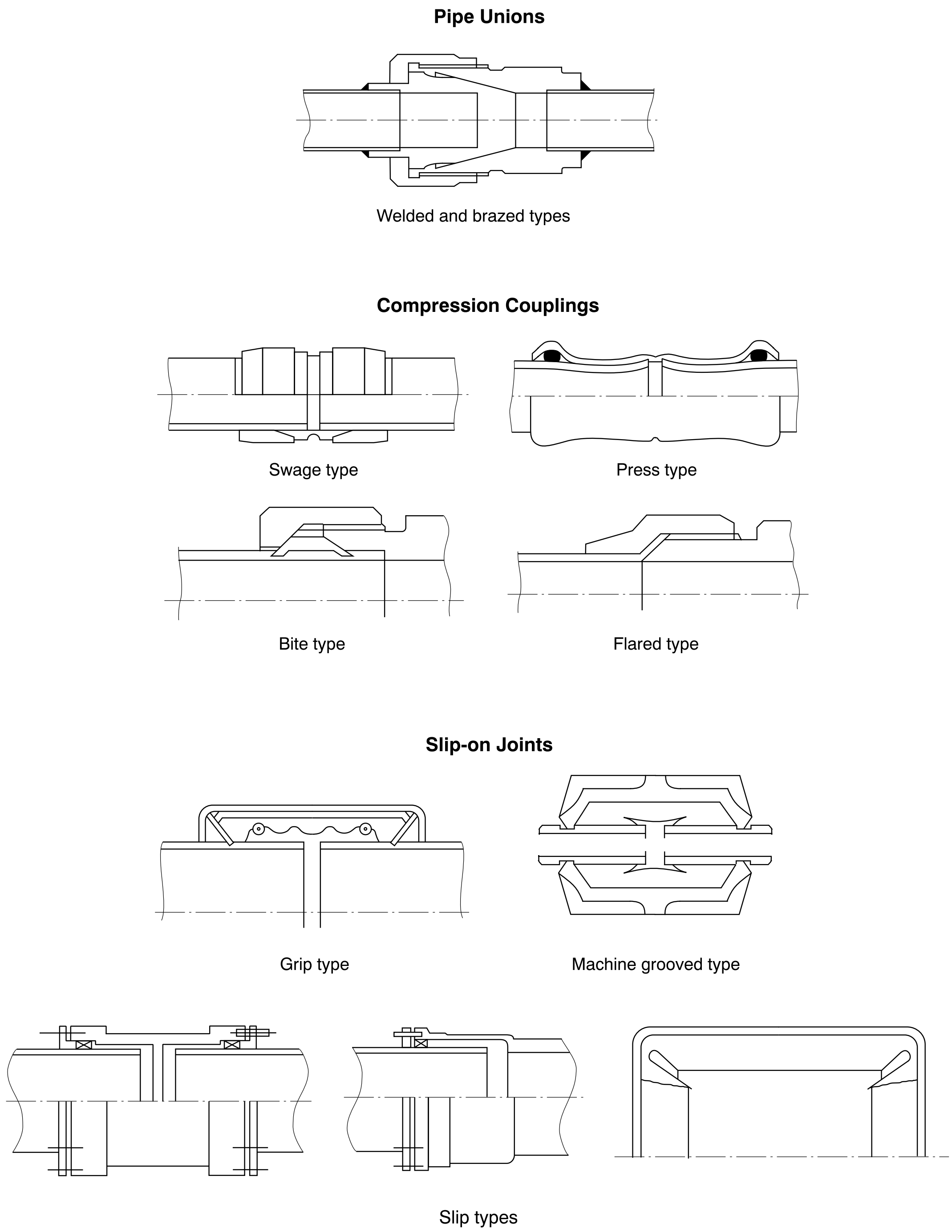
m) In some particular cases, sizes in excess of those mentioned above may be accepted by the Society if they are in compliance with a recognised national and/or international standard.

n) Application of various mechanical joints may be accepted as indicated by Tab 18. However, in all cases, acceptance of the joint type is to be subject to approval for the intended application, and subject to conditions of the approval and applicable Rules.

o) Mechanical joints are to be tested in accordance with a program approved by the Society, which is to include at least the following:

   1) leakage test
   2) vacuum test (where necessary)
   3) vibration (fatigue) test
   4) fire endurance test (where necessary)
   5) burst pressure test
   6) pressure pulsation test (where necessary)
   7) assembly test (where necessary)
   8) pull out test (where necessary).

Figure 2 : Examples of mechanical joints



2.4 Welding and bending of metallic piping

2.4.1 Welding of metallic piping

The provisions of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 10, [3] apply to the design, preparation, post-weld treatment and inspection of welded joints of metallic piping.

2.4.2 Bending of metallic piping

The provisions of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 10, [4] apply to the bending process and heat treatment after bending of metallic piping.

Table 18 : Application of mechanical joints

	Systems	Kind of connections		
		Pipe unions	Compression couplings **(1)**	Slip-on joints
	Flammable fluids (flash point ≤ 60°C)			
1	Vent lines	+	+	+ **(2)**
	Flammable fluids (flash point > 60°C)			
2	Fuel oil lines	+	+	+ **(2) (3)**
3	Lubricating oil lines	+	+	+ **(2) (3)**
4	Hydraulic oil	+	+	+ **(2) (3)**
	Sea water			
5	Bilge lines	+	+	+ **(4)**
6	Fire main and water spray	+	+	+ **(2)**
7	Foam system	+	+	+ **(2)**
8	Sprinkler system	+	+	+ **(2)**
9	Ballast system	+	+	+ **(4)**
10	Cooling water system	+	+	+ **(4)**
11	Non-essential systems	+	+	+
	Fresh water			
12	Cooling water system	+	+	+ **(4)**
13	Condensate return	+	+	+ **(4)**
14	Non-essential systems	+	+	+
	Sanitary/Drains/Scuppers			
15	Deck drains (internal)	+	+	+ **(5)**
16	Sanitary drains	+	+	+
17	Scuppers and discharge (overboard)	+	+	–
	Sounding/Vent			
18	Water tanks / Dry spaces	+	+	+
19	Oil tanks (flash point > 60°C)	+	+	+ **(3) (2)**
	Miscellaneous			
20	Starting / Control air **(4)**	+	+	–
21	Service air (non-essential)	+	+	+
23	CO_2 system **(4)**	+	+	–

Note 1: + : Application is allowed; – : Application is not allowed

(1) If compression couplings include any components which readily deteriorate in case of fire, they are to be of approved fire resistant type as required for slip-on joints.

(2) Approved fire resistant types.

(3) Not inside machinery spaces of category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.

(4) Inside machinery spaces of category A - only approved fire resistant types.

(5) Above free board deck only.

Table 19 : Application of mechanical joints depending upon the class of piping

Types of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe Unions			
Welded and brazed types	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Compression Couplings			
Swage type	+	+	+
Bite type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Flared type	+ (OD ≤ 60,3 mm)	+ (OD ≤ 60,3 mm)	+
Press type	–	–	+
Slip-on Joints			
Machine grooved type	+	+	+
Grip type	–	+	+
Slip type	–	+	+

Note 1: + : Application is allowed; – : Application is not allowed

3 Design of plastic piping systems

3.1 General

3.1.1 Application

These requirements are applicable to all piping systems with parts made of rigid plastic.

3.1.2 Use of plastic pipes

Plastic may be used in piping systems in accordance with the provisions of Tab 6, provided the following requirements are complied with.

3.1.3 Type approval

Plastic piping used for essential services and if used in circuits where in case of damage of the pipe the safety of the yacht is impaired are to be type approved.

3.1.4 Marking

Plastic pipes and fittings are to be permanently marked with identification, including:

- pressure ratings
- the design standards that the pipe or fitting is manufactured in accordance with
- the material of which the pipe or fitting is made.

3.2 Definitions

3.2.1 Plastic

Plastic includes both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and FRP (reinforced plastics pipes).

3.2.2 Piping systems

Piping systems include the pipes, fittings, joints, and any internal or external liners, coverings and coatings required to comply with the performance criteria.

3.2.3 Joints

Joints include all pipe assembling devices or methods, such as adhesive bonding, laminating, welding, etc.

3.2.4 Fittings

Fittings include bends, elbows, fabricated branch pieces, etc. made of plastic materials.

3.2.5 Nominal pressure

Nominal pressure is the maximum permissible working pressure which is to be determined in accordance with [3.3.3].

3.2.6 Fire endurance

Fire endurance is the capability of the piping system to perform its intended function, i.e. maintain its strength and integrity, for some predicted period of time while exposed to fire. The indication L3, used in Tab 6, refers to a 30 min fire endurance test in wet conditions in accordance with IMO Res.A753(18).

3.3 Strength

3.3.1 General

a) The piping is to have sufficient strength to take account of the most severe concomitant conditions of pressure, temperature, the weight of the piping itself and any static and dynamic loads imposed by the design or environment.

b) The strength of the pipes is to be determined at the maximum possible working temperature by the tests mentioned in [3.7.1].

3.3.2 Pipe thickness

Plastic pipes thickness is to be calculated using a maximum allowable stress not higher than 1/7 of the ultimate tensile strength of the material at the service temperature.

3.3.3 Permissible pressure

Piping systems are to be designed for a nominal pressure determined from the following conditions:

a) Internal pressure

The nominal internal pressure is not to exceed the smaller of:

- $P_{sth} / 4$
- $P_{lth} / 2,5$

where:

P_{sth} : Short-term hydrostatic test failure pressure, in MPa

P_{lth} : Long-term hydrostatic test failure pressure (> 100 000 hours), in MPa

b) External pressure (to be considered for any installation subject to vacuum conditions inside the pipe or a head of liquid acting on the outside of the pipe)

The nominal external pressure is not to exceed:

$P_{col} / 3$

where:

P_{col} : Collapse pressure

Note 1: The external pressure is the sum of the vacuum inside the pipe and the static pressure head outside the pipe.

c) The collapse pressure is not to be less than 0,3 MPa.

3.3.4 Permissible temperature

a) In general, plastic pipes are not to be used for media with a temperature above 60°C or below 0°C, unless satisfactory justification is provided to the Society.

b) The permissible working temperature range depends on the working pressure and is to be justified by appropriate tests.

c) The maximum permissible working temperature is to be at least 20°C lower than the minimum heat distortion temperature of the pipe material, determined according to ISO 75 method A or equivalent.

d) The minimum heat distortion temperature is not to be less than 80°C.

3.3.5 Axial strength

a) The sum of the longitudinal stresses due to pressure, weight and other loads is not to exceed the allowable stress in the longitudinal direction.

b) In the case of fibre reinforced plastic pipes, the sum of the longitudinal stresses is not to exceed half of the nominal circumferential stress derived from the nominal internal pressure condition (see [3.3.3]).

3.3.6 Impact resistance

Plastic pipes and joints are to have a minimum resistance to impact in accordance with a recognised national or international standard.

3.4 Fire safety characteristics

3.4.1 Fire endurance

The indication L3, used in Tab 6, refers to a 30 min fire endurance testing under wet conditions in accordance with IMO Res.A753(18).

3.4.2 Flame spread

The following applies for yachts over 500 GT:

a) All pipes, except those fitted on open decks and within tanks, cofferdams, pipe tunnels and ducts, are to have low spread characteristics not exceeding average values listed in IMO Resolution A.653(16). Other recognised national standards may also be referred to

b) Surface flame characteristics are to be determined using the procedure given in IMO Res. A.653(16) with regard to the modifications due to the curvilinear pipe surfaces as listed in Appendix 3 of Res. A.753(18).

3.4.3 Fire protection coating

Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance level required, it is to meet the following requirements:

- The pipes are generally to be delivered from the manufacturer with the protective coating on
- The fire protection properties of the coating are not to be diminished when exposed to salt water, oil or bilge slops. It is to be demonstrated that the coating is resistant to products likely to come into contact with the piping
- In considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations and elasticity are to be taken into account
- The fire protection coatings are to have sufficient resistance to impact to retain their integrity.

3.4.4 Electrical conductivity

a) Piping systems conveying fluids with a conductivity less than 1000 pS/m (1 pS/m = 10^{-9} siemens per meter), such as refined products and distillates, are to be made of conductive pipes.

b) Regardless of the fluid to be conveyed, plastic pipes passing through hazardous areas are to be electrically conductive.

c) Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed:

1×10^5 Ohm/m.

d) Where pipes and fittings are not homogeneously conductive, conductive layers are to be provided, suitably protected against the possibility of spark damage to the pipe wall.

3.5 Pipe and fitting connections

3.5.1 General

a) The strength of connections is not to be less than that of the piping system in which they are installed.

b) Pipes and fittings may be assembled using adhesive-bonded, welded, flanged or other joints.

c) When used for joint assembly, adhesives are to be suitable for providing a permanent seal between the pipes and fittings throughout the temperature and pressure range of the intended application.

d) Tightening of joints, where required, is to be performed in accordance with the manufacturer's instructions.

e) Procedures adopted for pipe and fitting connections are to be submitted to the Society for approval, prior to commencing the work.

3.5.2 Bonding of pipes and fittings

a) The procedure for making bonds is to be submitted to the Society for qualification. It is to include the following:
   - materials used
   - tools and fixtures
   - joint preparation requirements
   - cure temperature
   - dimensional requirements and tolerances
   - acceptance criteria for the test of the completed assembly.

b) When a change in the bonding procedure may affect the physical and mechanical properties of the joints, the procedure is to be requalified.

3.6 Arrangement and installation of plastic pipes

3.6.1 General

Plastic pipes and fittings are to be installed by the Shipyard in accordance with the Manufacturer's guidelines and taking account of the following provisions, as deemed necessary.

3.6.2 Supporting of pipes

a) Selection and spacing of pipe supports in shipboard systems are to be determined as a function of allowable stresses and maximum deflection criteria.

b) The selection and spacing of pipe supports are to take into account the following data:
   - pipe dimensions
   - mechanical and physical properties of the pipe material
   - mass of pipe and contained fluid
   - external pressure
   - operating temperature
   - thermal expansion effects
   - load due to external forces
   - thrust forces
   - water hammer
   - vibrations
   - maximum accelerations to which the system may be subjected.

   Combinations of loads are also to be considered.

c) Support spacing is not to be greater than the pipe manufacturer's recommended spacing.

d) Each support is to evenly distribute the load of the pipe and its content over the full width of the support. Measures are to be taken to minimise wear of the pipes where they are in contact with the supports.

e) Heavy components in the piping system such as valves and expansion joints are to be independently supported.

3.6.3 Provisions for expansion

a) Suitable provision is to be made in each pipeline to allow for relative movement between pipes made of plastic and the steel structure, having due regard to:
   - the high difference in the coefficients of thermal expansion
   - deformations of the yacht's structure.

b) Calculations of the thermal expansions are to take into account the system working temperature and the temperature at which the assembly is performed.

3.6.4 Provisions of mechanical damage

a) When installing the piping, allowance is to be made for temporary point loads, where applicable. Such allowance is to include at least the force exerted by a load (person) of 100 kg at mid-span on any pipe of more than 100 mm nominal outside diameter.

b) Pipes are to be protected from mechanical damage where necessary.

3.6.5 Earthing

a) Where, in pursuance of [3.4.4], pipes are required to be electrically conductive, the resistance to earth from any point in the piping system is not to exceed 1×10^6 Ω.

b) Where provided, earthing wires are to be accessible for inspection.

3.6.6 Penetration of fire divisions and watertight bulkheads or decks

a) Where plastic pipes pass through "A" or "B" class divisions, arrangements are to be made to ensure that fire endurance is not impaired. These arrangements are to be tested in accordance with 'Recommendations for Fire Test Procedures for "A", "B" and "F" Bulkheads' (IMO Resolution A754 (18) as amended).

b) When plastic pipes pass through watertight bulkheads or decks, the watertight integrity of the bulkhead or deck is to be maintained. If the bulkhead or deck is also a fire division and destruction by fire of plastic pipes may cause the inflow of liquid from tanks, a metallic shut-off valve operable from above the freeboard deck is to be fitted at the bulkhead or deck.

3.7 Certification

3.7.1 Type approval

The requirements for testing, inspection and certification in the scope of type approval of plastic piping are indicated in NR467 Rules for Steel Ships, Pt C, Ch 1, App 3, [4].

3.7.2 Workshop tests

Each pipe and fitting is to be tested by the manufacturer at a hydrostatic pressure not less than 1,5 times the nominal pressure.

3.7.3 Testing after installation on board

a) Piping systems for essential systems are to be subjected to a hydrostatic test pressure of not less than 1,5 times the design pressure or 0,4 MPa, whichever is the greater.

b) Piping systems for non-essential services are to be checked for leakage under operational conditions.

c) For piping required to be electrically conductive, earthing is to be checked and random resistance testing is to be performed.

4 Design of flexible piping systems

4.1 General

4.1.1 Definition

Flexible piping are not metallic flexible pipes which are used for not limited lengths in piping systems as a replacement of metallic or plastic rigid piping as defined in [2] and [3]. No confusion is to be made with flexible hoses and expansion joints as defined in [5.3.1].

4.1.2 Documentation

a) The drawings of the flexible piping are to be submitted to the Society. These drawings are to indicate in particular:
- the manufacturer and the type
- the composition
- the physical and mechanical characteristics according to the temperature
- the characteristics of inflammability and the fire resistance
- eventually the resistance to the various products they are likely to come into contact with
- the diameter and thickness
- the type of junctions with the other pipes and fittings.

b) Flexible piping is to undergo type-tests defined in [4.2.4].

4.2 Design

4.2.1 Design - Construction

a) Flexible pipes are to be made of materials resisting to marine environment and to the fluid they are to convey.

b) Flexible pipes are to be designed so as to withstand:
- externally to hydrocarbons
- to internal pressure
- to vibrations.

c) Flexible pipes intended to convey oil or fuel are to be fire-resistant. Where a protective lining is provided for this purpose, it is to be impervious to hydrocarbons and hydrocarbon vapours.

d) If flexible pipes are intended to be fitted at pump suctions, in particular bilge pumps, they are to be so designed as to avoid any risk of collapsing due to the internal depression of the pipes.

e) Clips made of corrosion-resistant material may be used for the junction of flexible piping, with at least two clips at each end, except for oil and fuel circuits where crimped connections are to be used.

f) The bursting pressure of non-metallic hoses is not to be less than four times their maximum service pressure.

4.2.2 Conditions of use

a) Flexible piping may be used in accordance with the provisions of [1.6.4].

b) The position of the flexible piping is to be clearly shown on the piping drawings submitted to the Society.

c) Isolating valves are to be provided permitting the isolation of flexible pipes intended to convey fuel, oil or compressed air.

d) Flexible piping is not to be used between the ship's side and the ship side valves.

e) Flexible piping is not to be used for the part of bilge piping circuits going through compartments intended to contain oil fuel.

4.2.3 Installation

a) Flexible piping is to be so arranged as to be easily accessible.

b) They have to be supported by means of collars or similar devices, so that the hoses and the junctions are not submitted to excessive stresses in all the normal service conditions.

c) The parts of flexible piping which are likely to undergo shocks or frictions are to be adequately protected by means of shield or appropriate sleeve.

4.2.4 Type-tests

a) Each type of flexible pipe is to undergo:
   - a bursting test
   - an external hydrocarbon resistance test
   - a fire resistance test in the cases mentioned in [4.2.1], item c)
   - a collapse test in the cases mentioned in [4.2.1], item d)
   - eventually vibration and ageing tests.

   The tests are to be carried out on hoses having a significant length and fitted with connections as stated in [4.2.1], item e).

b) The fire resistance test is to be carried out in the following conditions; other test methods may apply after special examination.

   The hose is to be submitted to fire for 30 minutes at a temperature of 800°C, while water at the maximum service pressure is circulated inside the hose; the temperature of the water at the outlets is not to be less than 80°C. No leak is to be recorded during and after the test.

c) Flexible pipes granted with a type approval certificate issued by the Society for the intended conditions of use are exempted from type-tests.

4.2.5 Hydraulic tests

Each flexible pipe, together with its connections, is to undergo a hydraulic test under a pressure at least equal to 1,5 times the maximum service pressure.

5 Arrangement and installation of piping systems

5.1 General

5.1.1 Unless otherwise specified, piping and pumping systems covered by the Rules are to be permanently fixed on board ship.

5.2 Protection against overpressure

5.2.1 General

a) These requirements deal with the protection of piping systems against overpressure, with the exception of heat exchangers and pressure vessels, which are dealt with in NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 3.

b) Safety valves are to be sealed after setting.

5.2.2 Protection of flammable oil systems

Provisions are to be made to prevent overpressure in any flammable oil tank or in any part of the flammable oil systems, including the filling pipes.

5.2.3 Protection of pump and compressor discharges

a) Provisions are to be made so that the discharge pressure of pumps and compressors cannot exceed the pressure for which the pipes located on the discharge of these pumps and compressors are designed.

b) When provided on the pump discharge for this purpose, safety valves are to lead back to the pump suction or to any other suitable place.

c) The discharge capacity of the safety valves installed on pumps and compressors is to be such that the pressure at the discharge side cannot exceed by more than 10% the design pressure of the discharge pipe in the event of operation with closed discharge.

5.2.4 Protection of pipes

a) Pipes likely to be subjected to a pressure exceeding their normal working pressure are to be provided with safety valves or equivalent overpressure protecting devices.

b) In particular, pipes located on the low pressure side of pressure reducing valves are to be provided with safety valves unless they are designed for the maximum pressure on the high pressure side of the pressure reducing valve. See also [1.3.2] and [5.5.1].

c) The discharge capacity of the devices fitted on pipes for preventing overpressure is to be such that the pressure in these pipes cannot exceed the design pressure by more than 10%.

5.3 Flexible hoses and expansion joints

5.3.1 Definition

Flexible hoses and expansion joints are short flexible connection pieces between two parts of a piping system in order to allow a relative movement between these parts.

5.3.2 General

a) The Society may permit the use of flexible hoses and expansion joints, both in metallic and non-metallic materials, provided they are approved for the intended service.

b) Flexible hoses and expansion joints are to be of a type approved by the Society, designed in accordance with [5.3.4] and tested in accordance with [6.2.1].

c) Flexible hoses and expansion joints are to be installed in accordance with the requirements stated in [5.3.6].

d) Flexible hoses and expansion joints intended for piping systems with a design temperature below the ambient temperature will be given special consideration by the Society.

5.3.3 Documentation

The information, drawings and documentation listed in [1.2.1] and [1.2.2] are to be submitted to the Society for each type of flexible hose or expansion joint intended to be used.

5.3.4 Design of flexible hoses and expansion joints

a) Flexible pipes and expansion joints are to be made of materials resistant to the marine environment and to the fluid they are to convey. Metallic materials are to comply with [1.6].

b) Flexible pipes and expansion joints are to be designed so as to withstand:
   - external contact with hydrocarbons
   - internal pressure
   - vibrations
   - pressure impulses.

c) Flexible pipes intended to convey fuel oil or lubricating oil and end attachments are to be of fire-resisting materials of adequate strength and are to be constructed to the satisfaction of the Society.

   Where a protective lining is provided for this purpose, it is to be impervious to hydrocarbons and to hydrocarbon vapours.

d) Flexible pipes intended to convey:
   - gaseous fluid at a pressure higher than 1 MPa
   - fuel oil or lubricating oil,

   are to be fitted with a metallic braid.

e) As a general rule, flexible hoses are to be fitted with crimped connections or equivalent. For pipes subject to a pressure not exceeding 0,5 MPa, as well as for scavenge air and supercharge air lines of internal combustion engines, clips made of galvanised steel or corrosion-resistant material with thickness not less than 0,4 mm may be used.

   For flexible piping of 25 mm diameter and above not less than two clips are to be fitted at each end.

f) Flexible pipes and expansion joints are to be so designed that their bursting pressure at the service temperature is not less than 4 times their maximum service pressure, with a minimum of 2 MPa. Exemptions from this requirement may be granted for expansion joints of large diameter used on sea water lines.

g) The junctions of flexible hoses and expansion joints to their couplings are to withstand a pressure at least equal to the bursting pressure defined in item f).

h) Where necessary, non-metallic pipes and hoses are to show a suitable resistance against collapse due to external pressure or bending.

5.3.5 Conditions of use of flexible hoses and expansion joints

a) The use of flexible hoses and expansion joints is to be limited as far as practicable.

b) The position of flexible hoses and expansion joints is to be clearly shown on the piping drawings submitted to the Society.

c) The use of non-metallic expansion joints on pipes connected to sea inlets and overboard discharges will be given special consideration by the Society. As a rule, the fitting of such joints between the yacht side and the valves mentioned in [5.4.5] is not permitted. Furthermore, unless the above-mentioned valves are fitted with remote controls operable from places located above the freeboard deck, efficient means are to be provided, wherever necessary, to limit the flooding of the yacht in the event of rupture of the expansion joints.

d) Expansion joints may be fitted in sea water lines, provided they are arranged with guards which effectively enclose, but do not interfere with, the action of the expansion joints and reduce to the minimum practicable any flow of water into the machinery spaces in the event of failure of the flexible elements.

e) Use of expansion joints in water lines for other services, including ballast lines in machinery spaces, in duct keels and inside double bottom water ballast tanks, and bilge lines inside double bottom tanks and deep tanks, will be given special consideration by the Society.

5.3.6 Installation of flexible hoses and expansion joints

a) Flexible hoses and expansion joints are to be so arranged as to be accessible at all times.

b) Flexible hoses and expansion joints are to be as short as possible.

c) The radius of curvature of flexible hoses is not to be less than the minimum recommended by the manufacturer.

d) The adjoining pipes are to be suitably aligned, supported, guided and anchored.

e) Isolating valves are to be provided permitting the isolation of flexible hoses intended to convey flammable oil or compressed air.

f) Expansion joints are to be protected against over extension or over compression.

g) Where they are likely to suffer external damage, flexible hoses and expansion joints of the bellows type are to be provided with adequate protection.

5.4 Valves and accessories

5.4.1 General

a) Valves and accessories are normally to be built in accordance with a recognised standard. Otherwise, they are subject to special consideration for approval by the Society.

Valves and fittings in piping systems are to be compatible with the pipes to which they are attached in respect of their strength (see [1.3.2] for design pressure) and are to be suitable for effective operation at the maximum working pressure they will experience in service.

Valves and accessories which are fitted:

- in a class I piping system, or
- in a class II piping system, or
- on the yacht side, on the collision bulkhead, on fuel oil tanks or on lubricating oil tanks under static pressure,

are to be subject to the applicable testing and inspection required by the Rules. See [6.6.1].

b) Shut-off valves are to be provided where necessary to isolate pumps, heat exchangers, pressure vessels, etc., from the rest of the piping system when necessary, and in particular:

- to allow the isolation of duplicate components without interrupting the fluid circulation
- for survey or repair purposes.

c) Cocks, valves and other accessories are generally to be arranged so that they are easily visible and accessible for manoeuvring, control and maintenance. They are to be installed in such a way as to operate properly.

d) Handles of valves or cocks are to be permanently fitted.

5.4.2 Design of valves and accessories

a) Materials of valve and accessory bodies are to comply with the provisions of [1.6].

b) connections of valves and accessories with pipes are to respect the same rules as for connections between pipes

c) All valves and accessories are to be so designed as to prevent the loosening of covers and glands when they are operated.

d) Valves are to be so designed as to shut with a right-hand (clockwise) motion of the wheels.

e) Valves are to be provided with local indicators showing whether they are open or shut, unless this is readily apparent.

5.4.3 Valves with remote control

a) All valves which are provided with remote control are also to be designed for local manual operation.

b) The remote control system and means of local operation are to be independent. In this respect, arrangement of the local operation by means of a fixed hand pump is to be specially considered by the Society.

c) In the case of valves which are to be provided with remote control in accordance with the Rules, opening and/or closing of the valves by local manual means is not to render the remote control system inoperable.

d) Power failure of the remote control system is not to cause an undesired change of the valve position.

5.4.4 Valves for sea inlets and overboard arrangements

a) The valves required in Ch 1, Sec 6, [3] together with their hull connections are not to substantially lower the hull resistance.

b) In sea water systems, hoses are to be secured by at least 2 clips. Hose clamps are to be made of austenitic stainless steel or equivalent.

c) Sea inlets and overboard discharges are to be fitted with valves complying with [5.4], [5.4.5] and [5.4.6].

d) Sea inlets are to be so designed and arranged as to limit turbulence and to avoid the admission of air due to motion of the yacht.

e) Sea inlets are to be fitted with gratings complying with [5.4.7].

f) Provisions are to be made for clearing sea inlet gratings.

g) Sea chests are to be suitably protected against corrosion.

5.4.5 Fitting of valves for metallic hulls

a) Sea inlet and overboard discharge valves are to be secured:
   - directly on the shell plating, or
   - on sea chests built on the shell plating, with scantlings in compliance with Part B of the Rules, or
   - on extra-reinforced and short distance pieces attached to the shell (see Tab 7).

b) The bodies of the valves and distance pieces are to have a spigot passing through the plating without projecting beyond the external surface of such plating or of the doubling plates and stiffening rings, if any.

c) Valves are to be secured by means of:
   - bolts screwed through the plating with a countersunk head, or
   - studs screwed in heavy pads themselves secured to the hull or chest plating, without penetration of the plating by the stud holes.

   Other screwing means be admitted by the Society, namely in the case of small size valves.

d) The use of butterfly valves is to be specially considered by the Society. In any event, butterfly valves not fitted with flanges are not to be used for water inlets or overboard discharges unless provisions are made to allow disassembling at sea of the pipes served by these valves without any risk of flooding.

5.4.6 Fitting of valves for wood or composite hulls

a) Suitable pads into which the attached fittings are spigotted are to be provided for the openings in the planking.

b) Other securing means may be accepted after special consideration in case of small size fittings.

5.4.7 Gratings

a) Gratings are to have a free flow area not less than twice the total section of the pipes connected to the inlet.

b) When gratings are secured by means of screws with a countersunk head, the tapped holes provided for such screws are not to pass through the plating or doubling plates outside distance pieces or chests.

c) Screws used for fixing gratings are not to be located in the corners of openings in the hull or of doubling plates.

d) In the case of large sea inlets, the screws used for fixing the gratings are to be locked and protected from corrosion.

e) When gratings are cleared by use of compressed air or steam devices, the chests, distance pieces and valves of sea inlets and outlets thus arranged are to be so constructed as to withstand the maximum pressure to which they may be subjected when such devices are operating.

5.4.8 Materials of valves

a) The materials of the valve bodies and connecting pieces are to comply with Tab 5.

b) The combination of different materials has to take into consideration the possibility of galvanic action.

5.4.9 Nameplates

a) Accessories such as cocks and valves on the fluid lines referred to in this Section are to be provided with nameplates indicating the apparatus and lines they serve except where, due to their location on board, there is no doubt as to their purpose.

b) Nameplates are to be fitted at the upper part of air and sounding pipes.

5.5 Control and monitoring

5.5.1 General

a) local indicators are to be provided for at least the following parameters:
   - pressure, in pressure vessels, at pump or compressor discharge, at the inlet of the equipment served, on the low pressure side of pressure reducing valves
   - temperatures, in tanks and ships, at heat exchanger inlet and outlet
   - levels, in tanks containing liquids.

b) safeguards are to be provided where an automatic action is necessary to restore acceptable values for a faulty parameter

c) automatic controls are to be provided where it is necessary to maintain parameters related to piping systems at a pre-set value.

5.5.2 Level indication

A level indication is to be provided for tanks intended to contain liquids as well as for all compartments which are not readily accessible at all times.

The following systems may be accepted:

a) sounding pipes in accordance with Ch 1, Sec 7, [3.1]

b) level gauges of an approved type, efficiently protected against shocks

   Level gauges for use in flammable oil systems are also subject to the following conditions:
   - cylindrical gauges may be used provided they are fitted with self-closing valves at their lower end as well as at their upper end if the latter is below the maximum liquid level
   - in the case of tanks not subject to filling by power pumps, with the exception of fuel oil service tanks, the valves need not to be of the self-closing type. Such valves are, however, to be readily accessible and instruction plates are to be fitted adjacent to them to specify that they are to be kept closed
   - the level gauges are not to be fitted in passenger or crew spaces.

c) a remote level gauging system of an approved type.

5.5.3 Temperature indication

Thermometers and other temperature-detecting elements in fluid systems under pressure are to be provided with pockets built and secured so that the thermometers and detecting elements can be removed while keeping the piping under pressure.

5.5.4 Pressure indication

Pressure gauges and other similar instruments are to be fitted with an isolating valve or cock at the connection with the main pipe.

5.6 Location of tanks and piping system components

5.6.1 Flammable oil systems

Location of tanks and piping system components conveying flammable fluids under pressure is to comply with [5.13].

5.6.2 Piping systems with open ends

Attention is to be paid to the requirements for the location of open-ended pipes on board ships having to comply with the provisions of [5.9].

5.6.3 Pipe lines located inside tanks

a) The passage of pipes through tanks, when permitted, normally requires special arrangements such as reinforced thickness or tunnels, in particular for:
   - bilge pipes
   - ballast pipes
   - scuppers and sanitary discharges
   - air, sounding and overflow pipes
   - fuel oil pipes.

b) Junctions of pipes inside tanks are to be made by welding or flange connections. See also [2.3.3].

5.6.4 Overboard discharges

Overboard discharges are to be so located as to prevent any discharge of water into the lifeboats while they are being lowered.

5.6.5 Piping and electrical apparatus

As far as possible, pipes are not to pass near switchboards or other electrical apparatus. If this requirement is impossible to satisfy, gutterways or masks are to be provided wherever deemed necessary to prevent projections of liquid or steam on live parts.

5.7 Passage through watertight bulkheads or decks

5.7.1 Penetration of watertight bulkheads and decks

a) Where penetrations of watertight bulkheads and internal decks are necessary for piping and ventilation, arrangements are to be made to maintain the watertight integrity.

b) Lead or other heat sensitive materials are not to be used in piping systems which penetrate watertight subdivision bulkheads or decks, where deterioration of such systems in the event of fire would impair the watertight integrity of the bulkhead or decks.

   This applies in particular to the following systems:
   - bilge system
   - ballast system
   - scuppers and sanitary discharge systems.

c) Where bolted connections are used when passing through watertight bulkheads or decks, the bolts are not to be screwed through the plating. Where welded connections are used, they are to be welded on both sides of the bulkhead or deck.

d) Penetrations of watertight bulkheads or decks by plastic pipes are to comply with [3].

5.7.2 Passage through the collision bulkhead

a) On yachts over 500 GT, a maximum of two pipes may pass through the collision bulkhead below the freeboard deck, unless otherwise justified. Such pipes are to be fitted with suitable valves operable from above the freeboard deck and the valve chest is to be secured at the bulkhead inside the fore peak. Such valves may be fitted on the after side of the collision bulkhead provided that they are readily accessible under all service conditions and the space in which they are located is not a cargo space. All valves are to be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable.

b) The remote operation device of the valve referred to in a) is to include an indicator to show whether the valve is open or shut.

5.8 Independence of lines

5.8.1 As a general rule, bilge and ballast lines are to be entirely independent and distinct from lines conveying lubricating oil and fuel oil, with the exception of:

- pipes located between collecting boxes and pump suctions
- pipes located between pumps and overboard discharges
- pipes supplying compartments likely to be used alternatively for ballast, fuel oil, provided such pipes are fitted with blind flanges or other appropriate change-over devices, in order to avoid any mishandling.

5.9 Prevention of progressive flooding

5.9.1 Application

The following requirements apply for yachts having the navigation notation unrestricted navigation and a length L greater than 85 m.

5.9.2 Principle

In order to comply with the damage stability requirements of Pt B, Ch 3, Sec 3, [1.1.2], provision is to be made to prevent any progressive flooding of a dry compartment served by any open-ended pipe, in the event that such pipe is situated outboard of a line drawn at one fifth of the breadth of the ship (and therefore considered damaged) inside the considered flooded compartment.

5.9.3 Piping arrangement

a) In order to respect [5.9.2], no pipe with an open end should normally be situated outboard a line at one fifth of the breadth of the yacht except where the section of such pipe does not exceed 50 cm^2.

Note 1: Where several pipes are considered, the limit of 50 cm^2 applies to their total section.

b) Where the provisions of a) cannot be fulfilled, and after special examination by the Society, pipes may be situated within the assumed transverse extent of damage penetration provided that:
   - either a closable valve operable from above the bulkhead deck is fitted at each penetration of a watertight subdivision and secured directly on the bulkhead, or
   - a closable valve operable from above the bulkhead deck is fitted at each end of the pipe concerned, the valves and their control system being inboard of the assumed extent of damage, or
   - the tanks to which the pipe concerned leads are regarded in the damage stability calculations as being flooded when damage occurs in a compartment through which the pipe passes.

c) Valves required to be operable from above the bulkhead deck are to be fitted with an indicator to show whether the valve is open or shut.

   Where the valve is remote controlled by other than mechanical means, and where the remote control system is located, even partly, within the assumed extent of damage penetration, this system is to be such that the valve is automatically closed by loss of power.

d) Air and overflow pipes are to be so arranged as to prevent the possibility of flooding of other tanks in other watertight compartments in the event of any one tank being flooded.

This arrangement is to be such that in the range of positive residual righting levers beyond the angle of equilibrium stage of flooding, the progressive flooding of tanks or watertight compartments other than that flooded does not occur.

5.10 Provision for expansion

5.10.1 General

Piping systems are to be so designed and pipes so fixed as to allow for relative movement between pipes and the yacht's structure, having due regard to the:

- temperature of the fluid conveyed
- coefficient of thermal expansion of the pipes material
- deformation of the yacht's hull.

5.10.2 Fitting of expansion devices

All pipes subject to thermal expansion and those which, due to their length, may be affected by deformation of the hull, are to be fitted with expansion pieces or loops.

5.11 Supporting of the pipes

5.11.1 General

Unless otherwise specified, the fluid lines referred to in this Section are to consist of pipes connected to the yacht's structure by means of collars or similar devices.

5.11.2 Arrangement of supports

Shipyards are to take care that:

a) The arrangement of supports and collars is to be such that pipes and flanges are not subjected to abnormal bending stresses, taking into account their own mass, the metal they are made of, and the nature and characteristics of the fluid they convey, as well as the contractions and expansions to which they are subjected

b) Heavy components in the piping system, such as valves, are to be independently supported.

5.12 Protection of pipes

5.12.1 Protection against shocks

Pipes are to be efficiently protected against mechanical shocks, particularly in their most exposed parts.

5.12.2 Protection against corrosion and erosion

a) Pipes are to be efficiently protected against corrosion, particularly in their most exposed parts, either by selection of their constituent materials, or by an appropriate coating or treatment.

b) The layout and arrangement of sea water pipes are to be such as to prevent sharp bends and abrupt changes in section as well as zones where water may stagnate. The inner surface of pipes is to be as smooth as possible, especially in way of joints. Where pipes are protected against corrosion by means of galvanising or other inner coating, arrangements are to be made so that this coating is continuous, as far as possible, in particular in way of joints.

c) If galvanised steel pipes are used for sea water systems, the water velocity is not to exceed 3 m/s.

d) If copper pipes are used for sea water systems, the water velocity is not to exceed 2 m/s.

e) Arrangements are to be made to avoid galvanic corrosion.

5.12.3 Protection against frosting

Pipes are to be adequately insulated against cold wherever deemed necessary to prevent frost.

This applies specifically to pipes passing through refrigerated spaces and which are not intended to ensure the refrigeration of such spaces.

5.12.4 Protection of high temperature pipes and components

a) All pipes and other components where the surface temperature may exceed 80°C are to be efficiently insulated. Where necessary, precautions are to be taken to protect the insulation from being impregnated with flammable oils.

b) Particular attention is to be paid to lagging in way of flanges.

5.12.5 Protection of flexible or heat sensitive pipes

a) Pipes made of heat sensitive materials are to be protected against contact with hot surfaces.

b) Flexible pipes are to be secured to rigid pipes or fittings by corrosion resistant clips or pressed ferrules. For flexible piping of 25 mm diameter and above not less than two clips are to be fitted at each end.

c) Where rubber or other heat sensitive material is used for hose, the run of hose is to be as direct as practicable, and the hose is to be adequately supported. If necessary, the hoses are to be protected against mechanical damage and contact with hot surfaces.

5.13 Additional arrangements for flammable fluids

5.13.1 General

The requirements in [5.13.3] and [5.13.4] apply to:

- fuel oil systems, in all spaces
- lubricating oil systems, in machinery spaces
- other flammable oil systems, in locations where means of ignition are present.

5.13.2 Prohibition of carriage of flammable oils in fore peak tanks

In yachts of more than 400 tons gross tonnage or carrying more than 12 passengers, fuel oil, lubricating oil and other flammable oils are not to be carried in fore peak tanks or tanks forward of the collision bulkhead.

5.13.3 Prevention of flammable oil leakage ignition

a) As far as practicable, the piping arrangement in the flammable oil systems is to comply generally with the following:
   - The conveying of flammable oils through accommodation and service spaces is to be avoided. Where it is not possible, the arrangement may be subject to special consideration by the Society, provided that the pipes are of a material approved having regard to the fire risk
   - The pipes are not to be located immediately above or close to the hot surfaces (exhaust manifolds, silencers, etc.), electrical installations or other sources of ignition. Otherwise, suitably protection (screening and effective drainage to the safe position) is to be provided to prevent of spraying or leakage onto the sources of ignition
   - Parts of the piping systems conveying heated flammable oils under pressure exceeding 0,18 MPa are to be placed above the platform or in any other position where defects and leakage can readily be observed. The machinery spaces in way of such parts are to be adequately illuminated.

b) No flammable oil tanks are to be situated where spillage or leakage therefrom can constitute a hazard by falling on:
   - hot surfaces, including those of heaters, exhaust manifolds and silencers
   - electrical equipment
   - air intakes
   - other sources of ignition.

c) Parts of flammable oil systems under pressure exceeding 0,18 MPa such as pumps, filters and heaters are to comply with the provisions of item b) above.

d) Mechanical joints, expansion joints and flexible parts of flammable oil lines are to be screened or otherwise suitably protected to avoid as far as practicable oil spray or oil leakages onto hot surfaces, into machinery air intakes, or on other sources of ignition.

e) Any relief valve of fuel oil and lubricating oil systems is to discharge to a safe position, such as an appropriate tank.

5.13.4 Provisions for flammable oil leakage containment

a) Tanks used for the storage of flammable oils together with their fittings are to be so arranged as to prevent spillages due to leakage or overfilling.

b) Drip trays with adequate drainage to contain possible leakage from flammable fluid systems are to be fitted:
   - under independent tanks
   - under burners
   - under purifiers and any other oil processing equipment
   - under pumps, heat exchangers and filters
   - under valves and all accessories subject to oil leakage
   - surrounding internal combustion engines.

c) The coaming height of drip trays is to be appropriate for the service and not less than 80 mm.

d) Where drain pipes are provided for collecting leakages, they are to be led to an appropriate drain tank.

5.13.5 Drain tank

a) The drain tank is not to form part of an overflow system and is to be fitted with an overflow alarm device.

b) In yachts required to be fitted with a double bottom, appropriate precautions are to be taken when the drain tank is constructed in the double bottom, in order to avoid flooding of the machinery space where drip trays are located, in the event of accidentally running aground.

5.13.6 Valves

All valves and cocks forming part of flammable oil systems are to be capable of being operated from readily accessible positions and, in machinery spaces, from above the working platform.

5.13.7 Level switches

Level switches fitted to flammable oil tanks are to be contained in a steel or other fire-resisting enclosure.

6 Certification, inspection and testing of piping systems

6.1 Application

6.1.1 This Article defines the certification and workshop inspection and testing programme to be performed on:

- the various components of piping systems
- the materials used for their manufacture.

On board testing is dealt with in Ch 1, Sec 10.

6.2 Type tests

6.2.1 Type tests of flexible hoses and expansion joints

a) Type approval tests are to be carried out on a flexible hose or an expansion joint of each type and each size, in accordance with Tab 20.

b) The flexible pipes or expansion joints subjected to the tests are to be fitted with their connections.

6.2.2 Type tests of air pipe closing appliances

Type approval tests are to be carried out on each type and size of air pipe closing device, in accordance with Tab 21.

6.3 Testing of materials

6.3.1 General

a) Detailed specifications for material tests are given in NR216 Materials and Welding.

b) Requirements for the inspection of welded joints are given in NR216 Materials and Welding.

Table 20 : Type tests to be performed for flexible hoses and expansion joints

Test	Flexible hoses and expansion joints in non-metallic material	Flexible hoses and expansion joints in metallic material
Bursting test	X	X
Fire-resistance test	X **(1)**	NR
Vibration test	X **(2)**	X **(2)**
Pressure impulse test	X	NR
Flexibility test	X **(3)**	X
Elastic deformation test	NR	X
Cyclic expansion test	X	X **(4)**
Resistance test	X **(5)**	X **(5)**

(1) Only for flexible hoses and expansion joints used in flammable oil and sea water systems.
(2) Only for flexible hoses and expansion joints fitted to engines, pumps, compressors or other sources of high vibrations.
(3) Only for flexible hoses conveying low temperature fluids.
(4) Only for piping systems subjected to expansion cycles.
(5) Internal to the conveyed fluid and external to UV.
Note 1: X = required, NR = not required.

6.3.2 Tests for materials

a) Where required in Tab 22, materials used for pipes, valves and other accessories are to be subjected to the following tests:
- tensile test at ambient temperature
- flattening test or bend test, as applicable
- tensile test at the design temperature, except if one of the following conditions is met:
  - the design temperature is below 200°C
  - the mechanical properties of the material at high temperature have been approved
  - the scantling of the pipes is based on reduced values of the permissible stress.

b) Plastic materials are to be subjected to the tests specified in [3].

Table 21 : Type tests to be performed for air pipe closing appliances

Test to be performed	Type of air closing appliance	
	Float type	Other types
Tightness test **(1)**	X	X
Flow characteristic determination **(2)**	X	X
Impact test of floats	X	
Pressure loading test of floats	X **(3)**	

(1) The tightness test is to be carried out during immerging/emerging in water, in the normal position and at an inclination of 40 degrees.
(2) Pressure drop is to be measured versus flow rate using water.
(3) Only for non-metallic floats.
Note 1: X = required.

Table 22 : Inspection and testing at works for piping systems and their components

N°	Item	Tests for materials **(1)**		Inspections and tests for the product **(1)**			Reference to the Rules
		Tests required	Type of material certificate **(2)**	During manufacturing (NDT)	After completion	Type of product certificate	
1	Valves, pipes and fittings						
	a) class I, d ≥ 50 mm or	X	C				[6.3.2]
	class II, d ≥ 100 mm			X **(3)**			**(4)**
					X	C **(5)**	[6.4.3]
	b) class I, d < 50 mm or	X	W				[6.3.2]
	class II, d < 100 mm			X **(3)**			**(4)**
					X	C **(5)**	[6.4.3]
2	Flexible hoses and expansion joints	X	W				[6.3.2]
					X	C **(5)**	[6.4.6]
3	Pumps and compressors						
	a) all				X	C **(5)**	[6.4.5]
	b) bilge and fire pumps				X	C **(5)**	[6.5.1]
4	Centrifugal separators				X	C **(5)**	[6.5.2]
5	Prefabricated pipe lines						
	a) class I and II with:						
	• d ≥ 65 mm, or			X **(3)**			**(4)**
	• t ≥ 10 mm				X	C **(5)**	[6.4.2]
	b) class I and II with:						
	• d < 65 mm, and			X **(3)**			**(4)**
	• t < 10 mm				X	W	[6.4.2]
	c) class III **(6)**				X	W	[6.4.2]

(1) X = test is required.
(2) C = class certificate ; W = works' certificate.
(3) If of welded construction.
(4) NR467 Rules for Steel Ship, Pt C, Ch 1, Sec10, [3.6.2] and [3.6.3].
(5) Or alternative type of certificate, depending on the Survey Scheme. See Part A.
(6) Where required by [6.4.2].

6.4 Hydrostatic testing of piping systems and their components

6.4.1 General

Pneumatic tests are to be avoided wherever possible. Where such testing is absolutely necessary in lieu of the hydraulic pressure test, the relevant procedure is to be submitted to the Society for acceptance prior to testing.

6.4.2 Hydrostatic pressure tests of piping

a) Hydrostatic pressure tests are to be carried out to the Surveyor's satisfaction for:
   - all class I and II pipes and their integral fittings
   - all compressed air pipes, and fuel oil and other flammable oil pipes with a design pressure greater than 0,35 MPa and their associated integral fittings.

b) These tests are to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

Note 1: Classes of pipes are defined in [1.5.2].

c) Pressure testing of small bore pipes (less than 15 mm) may be waived at the discretion of the Surveyor, depending on the application.

d) The test pressure is to be equal to 1,5 time the design pressure p.

e) Where it is necessary to avoid excessive stress in way of bends, branches, etc., the Society may give special consideration to the reduction of the test pressure to a value not less than 1,5 p. The membrane stress is in no case to exceed 90% of the yield stress at the testing temperature.

f) Hydrostatic testing may be carried out after assembly on board of the piping sections under the conditions stated in Ch 1, Sec 10, [3.7.1].

6.4.3 Hydrostatic tests of valves, fittings and heat exchangers

a) Valves and fittings non-integral with the piping system and intended for class I and II pipes are to be subjected to hydrostatic tests in accordance with standards recognised by the Society, at a pressure not less than 1,5 times the design pressure P defined in [1.3.2].

b) Valves and distance pieces intended to be fitted on the yacht side below the load waterline are to be subjected to hydrostatic tests under a pressure not less than 0,5 MPa.

c) The shells of appliances such as heaters, coolers and heat exchangers which may be considered as pressure vessels are to be tested under the conditions specified in NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 3.

d) The nests of tubes or coils of heaters, coolers and heat exchangers are to be submitted to a hydraulic test under the same pressure as the fluid lines they serve.

e) For coolers of internal combustion engines, see NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 2.

6.4.4 Hydrostatic tests of fuel oil bunkers and tanks not forming part of the yacht's structure

Fuel oil bunkers and tanks not forming part of the yacht's structure are to be subjected to a hydrostatic test under a pressure corresponding to the maximum liquid level in such spaces or in the air or overflow pipes, with a minimum of 2,40 m above the top. The minimum height is to be 3,60 m for tanks intended to contain fuel oil with a flashpoint below 60°C.

6.4.5 Hydrostatic tests of pumps and compressors

a) Cylinders, covers and casings of pumps and compressors are to be subjected to a hydrostatic test under a pressure at least equal to the test pressure p_H, in MPa, determined by the following formulae:
   - $p_H = 1,5\ p$ where $p \leq 4$
   - $p_H = 1,4\ p + 0,4$ where $4 < p \leq 25$
   - $p_H = p + 10,4$ where $p > 25$

   with:

   p : Design pressure, in MPa, as defined in [1.3.2].

   p_H is not to be less than 0,4 MPa.

b) Intermediate coolers of compressors are to undergo a hydrostatic test under a pressure at least equal to the pressure p_H defined in a). When determining p_H, the pressure p to be considered is that which may result from accidental communication between the cooler and the adjoining stage of higher pressure, allowance being made for any safety device fitted on the cooler.

c) The test pressure for water spaces of compressors and their intermediate coolers is not to be less than 1,5 times the design pressure in the space concerned, subject to a minimum of 0,2 MPa.

d) For air compressors and pumps driven by internal combustion engines, refer to NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 2.

6.4.6 Hydrostatic test of flexible hoses and expansion joints

a) Each flexible hose or expansion joint, together with its connections, is to undergo a hydrostatic test under a pressure at least equal to twice the maximum service pressure, subject to a minimum of 1 MPa.

b) During the test, the flexible hose or expansion joint is to be repeatedly deformed from its geometrical axis.

6.5 Testing of piping system components during manufacturing

6.5.1 Pumps

Bilge and fire pumps are to undergo a performance test.

6.5.2 Centrifugal separators

Centrifugal separators used for fuel oil and lubricating oil are to undergo a running test, normally with a fuel water mixture.

6.6 Inspection and testing of piping systems

6.6.1 The inspections and tests required for piping systems and their components are summarised in Tab 22.

Section 5 Bilge Systems

1 General

1.1 Applications

1.1.1 This Section applies to bilge systems.

1.2 Principle

1.2.1 An efficient bilge pumping system is to be provided, capable of pumping from and draining any watertight compartment other than a space permanently appropriated for the carriage of fresh water, water ballast, fuel oil or liquid cargo and for which other efficient means of pumping are to be provided, under all practical conditions. Efficient means is to be provided for draining water from insulated holds.

Bilge pumping system is not intended at coping with water ingress resulting from structural or main sea water piping damage.

1.3 Materials and details

1.3.1 Materials used for piping and equipment as well general details are to be in compliance with Ch 1, Sec 4.

2 Yacht or charter yacht of length less than 24 m

2.1 Application

2.1.1 Scope

The following requirements apply to motor or sailing yacht of less than 24 metres in load line length.

2.1.2 Alternative arrangements for yacht having the navigation notation **sheltered area** or **coastal area** or **unrestricted navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2 may be agreed on a case by case basis.

2.2 General provisions

2.2.1 Principle

A bilge pumping system or means capable to efficiently draining out water from any compartment of the boat is to be provided.

2.2.2 Pumps number

Depending of the boat length, the bilge system is to be at least:

- one portable manual pump, for length less than 5,5 m
- two manual pumps (one of which may be a portable pump), for length between 5,5 m and 10 m
- one manual pump and one power pump, for length between 10 m and 24 m.MM

2.2.3 Drained watertight compartments

A watertight compartment less than 7% of the total under deck volume may be drained into the adjacent compartment by means of a self-closing valve or cock. The valve or cock are to be fitted outside the compartment to be drained and are to be operable from a readily accessible position.

2.2.4 Open yacht

For open yacht having an overall length not greater than 5,5 m where there is no subdivision of the bottom by means of floors, buckets or bailers may be used in lieu of the manual bilge pumping system.

2.2.5 Progressive flooding

Where a permanent, fixed bilge pumping system is installed, care must be taken to preclude the risk of water flowing from one compartment to another by way of the bilge suction pipes. The bilge connection to any pump which draws from the sea is to be either a screw-down non return-valve or a cock which cannot be opened at the same time to the bilges and to the sea.

2.2.6 Electrical pumps

The electrically operated bilge-pumps are to be in accordance with international standard ISO 8849 when rated for less than 50 V direct current.

2.2.7 Bilge level device

A bilge level device connected to an audible or visible alarm should be fitted in all yachts where the propelling machinery is below deck level and not visible from the steering position.

With the machinery operating under full power conditions, the alarm, when operated, is to be clearly audible or visible at the steering position.

2.3 Bilge pumps

2.3.1 Bilge pumps capacity

a) The power bilge pumping capacity is not to be less than the value given by the formula:

$$Q = \frac{d^2}{300}$$

where:

Q : Minimum capacity of each pump, in m^3/h

d : Internal diameter, in mm, of the bilge main.

The internal diameter d, in mm, of the bilge main, is to be of the commercial size nearest to the diameter given in the following formula:

$$d = \frac{L}{1.2} + 25$$

where:

L : Rule length of the yacht, in m, defined in Pt B, Ch 1, Sec 2.

b) In no case the capacity of the power pumps is to be less than 2,7 m^3/h.

The capacity of the manual pumps is not to be less than 0,7 litre per stroke.

2.3.2 Pumps, valves and suctions location

Bilge pumps are to be sited in suitable locations, and valves, or other accessories which control them are to be easily accessible. Suction pipes are to be located as deep down as is possible and equipped with terminal efficient strainers. Drain holes and limbers are to be arranged in floors and framing to facilitate an easy flow of water from all parts of the yacht to the pump suction.

2.3.3 Self-priming type pumps

Bilge pumps are to be of the self priming type.

2.3.4 Other services

Bilge pumps may be used for other services such as deck washing, fire extinguishing, or stand-by cooling water duty, provided the system can be isolated by three ways valve or non-return valve to preclude the possibility of flooding from sea to bilge, in the event of a valve or cock being accidentally left open.

2.3.5 Non-return valves

A non-return valve may be used, if necessary, to prevent an automatic bilge pump from cycling on-and-off due to back flow from the discharge line.

2.3.6 Non-submersible pumps

Motors of non-submersible bilge pumps are to be located above the maximum anticipated bilge water level.

2.3.7 Remote operation of bilge valves and pumps

Manually operated pumps and necessary control valves are to be located in such manner they can be operable from position above the waterline and outside the machinery space.

2.3.8 Overboard discharge

Overboard discharges on the hull are to be situated above the maximum heeled waterline (angle of 7° heel for non-sailing yacht and 30° heel for sailing yacht), unless a seacock is installed and there is a mean to prevent backflow into the yacht.

2.4 Bilge piping

2.4.1 Non-metallic pipes

Non-metallic pipe work and associated valves may be accepted, provided the material of such non-metallic pipe work and associated valves has an appropriate resistance to salt water, oil, heat and vibration and be capable of operating under suction without collapse (see Ch 1, Sec 4, [4]).

2.4.2 Connections

a) Clamping or devices for bilge piping systems are to be made of non-corrodable material.

b) The nominal bore of a manually operated pump is to be consistent with the bore of the associated piping.

3 Yacht or charter yacht equal to or over 24 m and less than 500 GT

3.1 Application

3.1.1 Scope

The following requirements apply to motor or sailing yacht of 24 metres in load line length and over, and of less than 500 tons gross tonnage.

3.1.2 Alternative arrangements for yacht having the navigation notation **sheltered area** or **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2 may be agreed on a case by case basis.

3.2 General provisions

3.2.1 Principle

All yachts are to be provided with efficient means for pumping and draining any watertight space with at least one suction pipe when the yacht is on an even keel and either is upright or has a list of up to 10°. This value could be reduced to 5° for multi-hull yachts and should be increased to 15° for monohull sailing yachts.

3.2.2 Multihull yachts

Bilge pumping of multihull yachts shall be specially considered by the Society. The “B” to be taking into account in [3.5.1] depends on the possibility of communication between hulls based on list angles indicated in [3.2.1].

3.2.3 Independence of the lines

As a general rule, bilge lines are to be entirely independent and distinct from other lines.

However, this requirement need not be applied to pipes located between collecting boxes and pump suctions or between pumps and overboard discharges.

3.2.4 Design of bilge systems

a) The bilge pumping system is to consist of pumps connected to a bilge main line so arranged as to allow the draining of all spaces through bilge branches, distribution boxes and bilge suctions, except for some small spaces where individual suctions by means of hand pumps may be accepted as stated in [3.6.2] and [3.6.3].

b) If deemed acceptable by the Society, bilge pumping arrangements may be dispensed with in specific compartments provided the safety of the yacht is not impaired.

3.2.5 Intactness of watertight subdivision

Bilge lines are to be so arranged as to avoid inadvertent flooding of any dry compartment.

The lines and accessories are to be so arranged as to prevent intercommunication of compartments which are to remain segregated from each other or the accidental connection of these compartments directly to the sea.

3.2.6 Number and distribution of suctions

a) Draining of watertight spaces is to be possible, when the yacht is on an even keel and either is upright or has a list in accordance with [3.2.1], by means of at least:
   - two suctions in machinery spaces, including one branch bilge suction and one direct suction
   - one suction in other spaces.

b) In all cases, arrangements are to be made such as to allow a free and easy flow of water to bilge suctions.

c) The suctions are to be located at the lowest points of the compartment.

d) Additional suctions may be required if the flow of water towards the suctions is disturbed by irregularities of the bottom.

3.2.7 Bilge level alarm

A bilge level device connected to an audible and visible alarm are to be fitted at the steering position.

3.3 Pumps and ejectors

3.3.1 Pumps

a) At least two power bilge pumps are to be provided; one of these pumps may be driven by a main propulsive engine.

b) The Society may permit, after special consideration, that one of the pumps be replaced by an ejector. In this case its suction capacity is not to be less than the required capacity of the pump it replaces.

c) The bilge pumps are to be connected to the bilge main mentioned in [3.2.4].

d) Small compartments may be drained by means of portable or fixed hand pumps.

3.3.2 Choice of the pumps

a) Bilge pumps are to be of the self-priming type. Centrifugal pumps are to be fitted with efficient priming means, unless an approved priming system is provided to ensure the priming of pumps under normal operating conditions.

b) Cooling water pumps connected to an emergency bilge suction need not be of the self-priming type.

c) Sanitary, ballast and general service pumps may be accepted as independent power bilge pumps if fitted with the necessary connections to the bilge pumping system.

d) Hand pumps are to have a maximum suction height not exceeding 7,30 m and to be operable from a position located above the load waterline.

3.3.3 Capacity of the pumps

The capacity of the bilge pumps is to be such that a speed of water not less than 1,22 m/s may be obtained in the bilge main the diameter of which is given in [3.5.1]. The capacity of each pump is therefore not to be less than:

$$Q = 0{,}00345\ d_1^2$$

where:

Q : Minimum capacity of each pump, in m^3/h

d_1 : Internal diameter, in mm, of the bilge main as defined in [3.5.1].

3.3.4 Use of other pumps for bilge duties

a) Other pumps may be used for bilge duties, such as fire, general service, sanitary service or ballast pumps, provided that:
   - they meet the capacity requirements
   - suitable piping arrangements are made
   - pumps are available for bilge duty when necessary.

b) The use of bilge pumps for fire duty is to comply with the provisions of Part C, Chapter 4.

3.3.5 Electrical supply of submersible pump motors

a) Where submersible bilge pumps are provided, arrangements are to be made to start their motors from a convenient position above the bulkhead deck.

b) Where an additional local-starting device is provided at the motor of a permanently installed submersible bilge pump, the circuit is to be arranged to provide for the disconnection of all control wires therefrom at a position adjacent to the starter installed on the deck.

3.4 Individual pumps

3.4.1 Alternative arrangement

As an alternative to [3.3.4], craft may be fitted with individual bilge pumps. In such case the total capacity Q_t of the bilge individual pumps for each hull is not to be less than 2,4 times the capacity of the pump defined in [3.3.3] and [3.5.1].

3.4.2 Individual pumps capacity

In bilge pumping arrangements where a bilge main is not provided, then, with the exception of the spaces forward of public spaces and crew accommodation, at least one fixed submersible pump is to be provided for each space. In addition, at least one portable pump is to be provided supplied from the emergency supply, if electric, for use on individual spaces. The capacity of each submersible pump Q_n is not to be less than:

$$Q_n = Q_t / (N - 1) \text{ ton/h with a minimum of } 6\ m^3/h$$

where:

Q_t : Total capacity as defined in [3.4.1]

N : Number of individual submersible pumps.

3.5 Size of bilge pipes

3.5.1 Bilge main

The internal diameter, in mm, of the bilge main, is to be of the commercial size nearest to the diameter given in the following formula, in mm:

$$d_1 = 1{,}68\sqrt{L(B + C)} + 25$$

where:

L : Rule length of the yacht, in m, defined in Pt B, Ch 1, Sec 2

B :
- for monohull craft: breadth of the yacht, in m, as defined in Pt B, Ch 1, Sec 2
- for multi-hull craft: see [3.2.2]

C : Moulded depth of the yacht, in m, at the freeboard deck.

In addition, d_1 is not to be less than 35 mm.

3.5.2 Suctions machinery spaces

The internal diameter, in mm, of bilge pipes situated between collecting boxes and suctions in holds and machinery spaces, is to be of the commercial size nearest to the diameter given by the following formula, in mm:

$$d_2 = 2{,}16\sqrt{L_1(B+C)} + 25$$

where:

B, C : Dimensions having the same meaning as in [3.5.1]

L_1 : Length of the compartment, in m.

In addition, d_2 is not to be less than 35 mm.

3.5.3 Direct suction

The direct suction is to be led directly to an independent power bilge pump and so arranged that it can be used independently of the main bilge line.

3.6 Draining of dry spaces other than machinery spaces

3.6.1 Draining of dry spaces

All spaces, as cofferdams or accommodations, are to be provided with suction pipes.

3.6.2 Draining of fore and aft peaks

Where the peaks, if any, are not used as tanks and bilge suctions are not fitted, drainage of both peaks may be effected by hand pump suction provided that the suction lift is well within the capacity of the pump and in no case exceeds 7,3 m.

3.6.3 Draining of spaces above fore and aft peaks

a) Provision is to be made for the drainage of the chain lockers and watertight compartments above the fore peak tank, if any, by hand or power pump suctions.

b) Steering gear compartments or other small enclosed spaces situated above the aft peak tank, if any, are to be provided with suitable means of drainage, either by hand or power pump bilge suctions. However, in the case of rudder stock glands located below the summer load line, the bilge suctions of the steering gear compartment are to be connected to the main bilge system.

3.7 Arrangement of bilge lines and their accessories

3.7.1 Passage of pipes through certain compartments

If not contained in pipe tunnels, the part of bilge pipes passing through compartments intended to contain oil fuel are to have reinforced thickness and are to consist of a single piece. These pipes are to be provided with non-return valves at their ends in the holds.

3.7.2 Passage through watertight bulkheads

No bilge cock or similar device is to be fitted on the collision bulkhead.

The fitting of bilge cocks or similar devices on other watertight bulkheads is to be avoided as far as possible. However, where such accessories are provided, they are to be accessible at any time and capable of being closed from positions above the deck. An indication is to be provided to show whether these valves are open or close.

3.7.3 Non-return valves

To prevent intercommunication of compartments or lines which are to remain segregated from each other, non-return valves or similar devices are to be fitted, namely on the pipe connections to bilge distribution boxes or to the alternative cocks, if any.

3.7.4 Strainers and mud boxes

a) Strainers are to be fitted on each bilge pump suction lines.

b) Mud boxes are to be fitted on bilge lines wherever they are necessary.

3.7.5 Access to valves and distribution boxes

All distribution boxes and manually operated valves in connection with the bilge pumping arrangement are to be in positions which are accessible under ordinary circumstances.

4 Yacht or charter yacht equal to or over 500 GT

4.1 Application

4.1.1 Scope

The following requirements apply to motor or sailing yacht of 500 tons gross tonnage and over.

In addition, the requirements of [3] are also to be complied with.

4.2 Principle

4.2.1 Bilge main

a) A bilge main is to be provided for draining the different compartments, as described in [3.2.4].

b) Individual pumps as defined in [3.4] are not permitted.

4.2.2 Availability

The bilge system is to be able to work while the other essential installations of the yacht, especially the fire-fighting installations, are in service.

4.3 Bilge pumps

4.3.1 Number and arrangement of pumps

a) Each pump may be replaced by a group of pumps connected to the bilge main, provided their total capacity meets the requirements specified in [4.3.2].

b) Alternative arrangements, such as the use of a hand pump in lieu of a power pump, will be given special consideration by the Society.

4.3.2 Capacity of the pumps

a) Each power bilge pump is to be capable of pumping water through the required main bilge pipe at a speed of not less than 2 m/s.

b) The capacity of each pump or group of pumps is not to be less than:

$Q = 0,00565\ d^2$

where:

Q : Minimum capacity of each pump or group of pumps, in m^3/h

d : Internal diameter, in mm, of the bilge main as defined in [3.5.1].

c) The capacity of hand pumps is to be based on one movement once a second.

5 Bilge pumping after flooding

5.1 Application

5.1.1 Yachts having the navigation notation **unrestricted navigation** and a length L_{LL} greater than 24 m but less than 85 m are to meet the requirements of [5.2].

5.1.2 Yachts having the navigation notation **unrestricted navigation** and a length L_{LL} equal to or greater than 85 m are to meet the requirements of [5.3].

5.1.3 Yachts having the navigation notation **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, and yachts under 300 UMS not engaged in trade, may be exempted from bilge pumping after flooding arrangements.

In addition, the requirements of [3] or [4] are also to be complied with, depending on the size of the yacht.

5.2 Bilge pumping arrangements after flooding for yachts with L ≤ 85 m

5.2.1 Principle

In case of one compartment flooded, the bilge system is to be able to drain any of the remaining non-flooded compartments. This operation shall not need any manual intervention inside the flooded compartment.

5.3 Bilge pumping arrangements after flooding for yachts with L > 85 m

5.3.1 Principle

In case of one compartment flooded, the bilge system is to be able to drain any of the remaining non-flooded compartments. This operation shall not need any manual intervention below the freeboard deck.

5.3.2 Piping arrangement

Distribution boxes, cocks, valves, pumps and piping are to be so arranged that in case of any part of the bilge system situated outboard of a line drawn at one fifth of the breadth of the ship shall not put the bilge system out of action.

5.3.3 Valve controls

All cocks and valves referred to which can be operated from above the bulkhead deck are to have their controls at their place of operation clearly marked and are to be provided with means to indicate whether they are open or closed.

Section 6 Scuppers and Discharges

1 General

1.1 Application

1.1.1 This Section applies to scuppers and discharges in accordance with the definitions indicated hereafter.

1.2 Materials and details

1.2.1 Materials used for piping and equipment as well as general details such as hull connections are to be in compliance with Ch 1, Sec 4.

1.3 Principle

1.3.1 Scuppers and discharges

a) Scuppers, sufficient in number and suitable in size, are to be provided to permit the drainage of water likely to accumulate in the spaces which are not located in the yacht's bottom.

b) The scupper and discharge piping systems are to be so arranged to reduce the risk of intake of seawater.

1.4 Definitions

1.4.1 Scuppers

Scuppers are piping systems for evacuation from or draining of open spaces situated above the free board deck. This includes the following arrangements:

- draining of exposed decks
- draining of open superstructures
- gravity sanitary evacuation from open superstructures.

1.4.2 Discharges

Discharges are piping systems for pump overboard discharges from spaces situated below the freeboard deck and evacuation from or draining of enclosed spaces situated above the freeboard deck. This includes the following arrangements:

- overboard discharges of pumps situated under the freeboard deck
- draining of enclosed superstructures
- gravity sanitary evacuation from enclosed superstructures.

1.4.3 Inboard end

The inboard end of discharge piping is the open end of the pipe situated inside the vessel opposite to the end where the discharge is led through the hull.

1.4.4 Other definitions

The following definitions are indicated in Pt B, Ch 2, Sec 2:

- freeboard deck
- superstructure
- open
- enclosed.

The following definition is indicated in Ch 4, Sec 12:

- vehicle space.

2 Scuppers and discharge arrangements

2.1 General

2.1.1 Amount of scuppers and discharges

The number of scuppers and sanitary discharge openings in the shell plating is to be reduced to a minimum either by making each discharge serve as many as possible of the sanitary and other pipes, or in any other satisfactory matter.

2.1.2 Discharge from galleys and their stores

Discharges from galleys and their stores, when these spaces form separate rooms, are to be kept separate from other discharges and be drained overboard or in separate drainage tanks; alternatively, discharges are to be provided with adequate devices against odours and overflow.

2.2 Self draining arrangements

2.2.1 Unprotected deck or open spaces

Adequate provisions are to be made to ensure the rapid freeing of the deck and cockpit from green seas water by self-draining measures.

2.2.2 Cockpits or enclosed wells

When in unprotected deck or open spaces bulkwards form an enclosed well where a large quantity of water is likely to accumulate, scuppers are to be arranged.

Unless justificatory calculations are submitted, scuppers of at least 32 mm in diameter are to be fitted on flat deck on both sides, every 6 m on the axial length, with a total scuppers section of at least 140 mm^2 per square meter of surface to be drained.

2.3 Drainage of vehicle spaces

2.3.1 Prevention of build-up of free surfaces

In vehicle spaces fitted with a fixed pressure water-spraying fire-extinguishing system, the drainage arrangement is to be such as to prevent the build-up of free surfaces. If this is not possible, the adverse effect upon stability of the added weight and free surface of water are to be taken into account to the extent deemed necessary by the Society in its approval of the stability information. Refer to Pt B, Ch 3, Sec 3.

2.3.2 Draining of vehicle spaces

Draining of enclosed (in accordance with Pt B, Ch 2, Sec 2) vehicle spaces are not to be led to machinery spaces or other places where sources of ignition may be present.

2.3.3 Draining of helidecks

Draining of helidecks is to be in compliance with Ch 4, Sec 11, [3.2].

3 Hull integrity

3.1 Application

3.1.1 The general requirements indicated in Pt B, Ch 2, Sec 2, [1] are also valid for the present Article.

3.1.2 Alternative arrangements for yacht having the navigation notation **sheltered area** or **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, or for yacht of less than 500 UMS may be agreed on a case by case basis.

3.2 Scuppers

3.2.1 General

Scuppers are to be led overboard. Exception is made for sanitary gravity evacuation systems which can be led to suitable sanitary tanks.

3.2.2 Normal arrangement

Scupper pipes originating at any level and led through the hull the hull below the freeboard deck are to be provided with a non-return valve at the hull. This valve may be omitted if one of the following conditions is fulfilled:

- the end connection with the hull is situated at less than 450 mm below the freeboard deck and more than 600 mm above the summer load water line
- the part of the scupper piping below the freeboard deck is of extra reinforced thickness in accordance with Ch 1, Sec 4, [1].

3.3 Discharges

3.3.1 General

Discharges can be led overboard or led to the bilge. In case of sanitary gravity evacuation systems, they are to be led either overboard or to suitable sanitary tanks.

3.3.2 Normal arrangement

Each separate discharge led through the shell plating is to be provided with:

- an automatic non-return valve fitted with a positive means of closing from a position above the freeboard deck
- an automatic non-return valve and one closing valve controlled from above the freeboard deck.

3.3.3 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0,01 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0,01 L, the discharge may have two automatic non-return valves without positive means of closing, provided that:

- the inboard valve is above the level of the tropical load waterline so as to always be accessible for examination under service conditions, or
- where this is not practicable, a locally controlled closing valve is interposed between the two automatic non-return valves.

3.3.4 Alternative arrangement when the inboard end of the discharge pipe is above the summer waterline by more than 0,02 L

Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0,02 L, the discharge may have a single automatic non-return valve without positive means of closing.

3.3.5 Arrangement of discharges through manned machinery spaces

Where discharges are led overboard through the hull in way of manned machinery spaces, the means of closing as indicated in [3.3.2] can be locally operated.

3.4 Specific arrangements

3.4.1 Sea inlets

Sea inlets are as a rule considered as discharges and therefore are to be in accordance with [3.3]. The automatic non-return valve with positive means of closing can be replaced by a closing valve.

3.4.2 Closed circuits

For closed circuits such as cooling system piping situated between the sea inlet and the overboard discharge, the automatic non-return valve with positive means of closing as required in [3.3.2] could be replaced by a closing valve to the discretion of the Society.

3.4.3 Pumps

Pumps forming part of discharge systems could be considered as an automatic non return valve if duly justified.

3.4.4 Remote control

The means of closing as indicated in [3.3.2] in other spaces as mentioned in [3.3.5] could be locally operated if it is duly justified that the valve is easily accessible and can be rapidly closed.

3.4.5 Engine exhaust gas outlets under freeboard deck

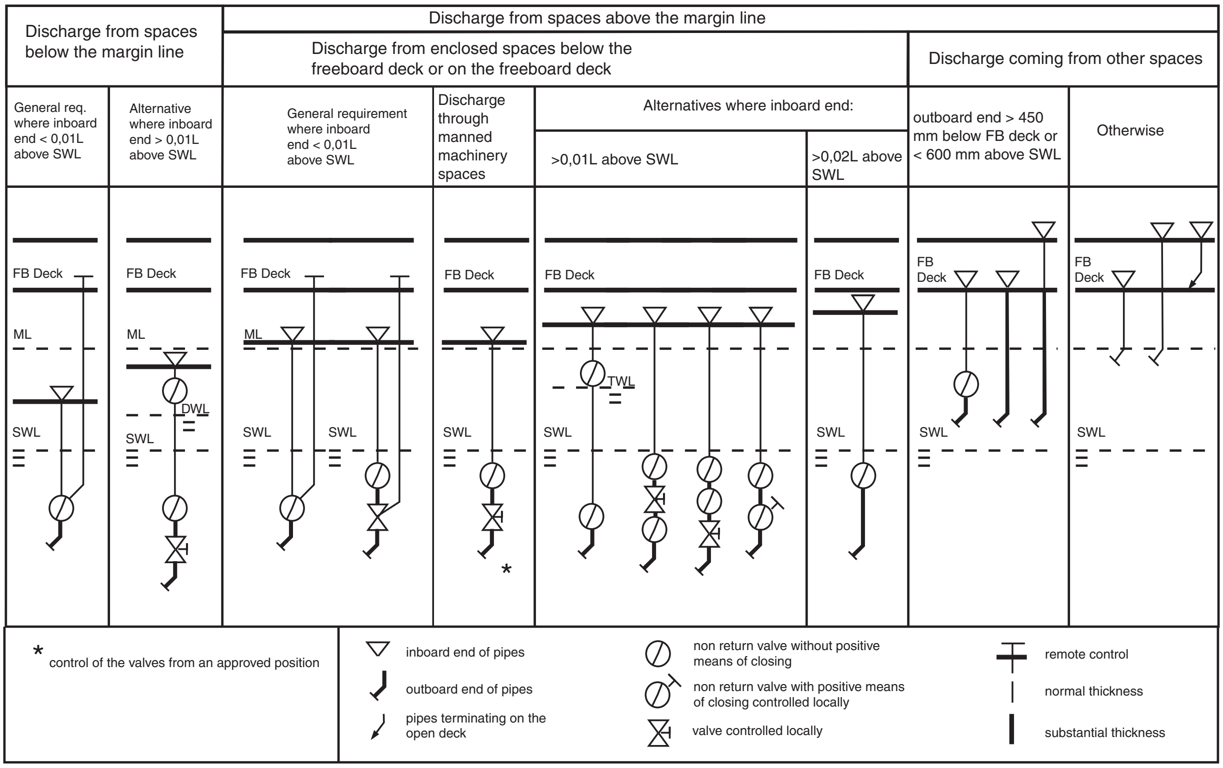
In addition to the provisions of Ch 1, Sec 9 related to engine protection, the hull connection in way of engine exhaust gas outlets under freeboard deck is to comply with one of the following features, in order to respect hull integrity:

- the connection with the hull is fitted with a means of closure or a non-return valve
- the exhaust pipe arrangement is looped above the waterline to a minimum height of 0,02 L_{LL} and the pipe construction is of a strength equivalent to that of the hull structure.

3.5 Summary table of scupper and overboard discharge arrangements

3.5.1 The various arrangements acceptable for scuppers and sanitary overboard discharges are summarised in Fig 1.

Figure 1 : Overboard discharge arrangement



Section 7 Air, Sounding and Overflow Pipes

1 General

1.1 Application

1.1.1 This Section applies to air, sounding and overflow pipes.

1.2 General arrangements

1.2.1 Materials and details

Materials used for piping and equipment as well as general details are to be in compliance with Ch 1, Sec 4.

1.2.2 Self-draining of pipes

Air pipes and overflow pipes are to be so arranged as to be self-draining when the yacht is on an even keel.

1.2.3 Name plates

Nameplates are to be fixed at the upper part of air pipes and sounding pipes.

2 Air pipes

2.1 Air pipe arrangements

2.1.1 Principle

Air pipes are to be fitted to all tanks, double bottoms, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements, in order to allow the passage of air or liquid so as to prevent excessive pressure or vacuum in the tanks or compartments, in particular in those which are fitted with piping installations. Their open ends are to be so arranged as to prevent the free entry of sea water in the compartments.

2.1.2 Number and position of air pipes

a) Air pipes are to be so arranged and the upper part of compartments so designed that air or gas likely to accumulate at any point in the compartments can freely evacuate.

b) Air pipes are to be fitted opposite the filling pipes and/or at the highest parts of the compartments.

c) Where only one air pipe is provided, it is not to be used as a filling pipe.

2.1.3 Location of open ends of air pipes

Air pipes are to be led above the freeboard deck in the following cases:

- fuel oil tanks
- lubrication oil and hydraulic oil tanks in contact with seawater (e.g. integrated side tanks)
- all tanks intended to be pumped up
- double bottom and other watertight compartments.

2.1.4 Special arrangements for air pipes of flammable oil tanks

a) Air pipes from fuel oil tanks are to discharge to a safe position on the open deck where no danger will be incurred from issuing oil or gases.

   Where fitted, wire gauze diaphragms are to be of corrosion resistant material and readily removable for cleaning and replacement. The clear area of such diaphragms is not to be less than the cross-sectional area of the pipe.

b) Air pipes of lubricating or hydraulic oil storage tanks not subject to flooding in the event of hull damage may be led to machinery spaces, provided that in the case of overflowing the oil cannot come into contact with electrical equipment, hot surfaces or other sources of ignition.

c) The location and arrangement of vent pipes for fuel oil service, settling and lubrication oil tanks are to be such that in the event of a broken vent pipe there is no risk of ingress of seawater or rainwater.

d) Air pipes of fuel oil service, settling and lubrication oil tanks likely to be damaged by impact forces are to be adequately reinforced.

e) for tanks of less than 30 litres capacity, separate vent pipes may be dispensed if the filling pipe is suitably arranged.

2.1.5 Special arrangements for air pipes of black water tanks

Air pipes from black water tanks are to discharge to a naturally ventilated position on the open deck.

2.1.6 Construction of air pipes

a) In each compartment likely to be pumped up, and where no overflow pipe is provided, the total cross-sectional area of air pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

b) Air pipes with height exceeding 900 mm are to be additionally supported.

2.2 Hull integrity

2.2.1 The general requirements indicated in Article Pt B, Ch 2, Sec 2, [1] are also valid for the present Article.

2.2.2 Alternative arrangements for yacht having the navigation notation **sheltered area** or **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2 may be agreed on a case by case basis.

2.2.3 Height of air pipes

a) The height of air pipes extending above the freeboard deck or superstructure deck from the deck to the point where water may have access below is to be at least:
   - 760 mm on the freeboard deck, and
   - 450 mm on the superstructure deck.

   This height is to be measured from the upper face of the deck, including sheathing or any other covering, up to the point where water may penetrate inboard.

b) Where these heights may interfere with the working of the yacht, a lower height may be approved, provided the Society is satisfied that this is justified by the closing arrangements and other circumstances. Satisfactory means which are permanently attached are to be provided for closing the openings of the air pipes.

c) The height of air pipes may be required to be increased on yachts for the purpose of compliance with buoyancy calculations.

   The air pipe of tanks other than oil tanks may discharge through the side of the superstructures.

d) The height of air pipes discharging through the side of the superstructure is to be at least 2,3 m above the summer load waterline.

e) For yacht having the navigation notation **sheltered area** or **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, and for yacht under 300 UMS not engaged in trade, the height of air pipes extending above the freeboard deck or superstructure deck from the deck to the point where water may have access below is to be at least:
   - 380 mm on the freeboard deck, and
   - 225 mm on the superstructure deck.

2.2.4 Fitting of closing appliances

a) Satisfactory appliances which are permanently attached are to be provided for closing the openings of air pipes in order to prevent the free entry of water into the spaces concerned.

b) An automatic closing appliance could be required on an air pipe end if compliance with stability rules depends on the automatic closing of this air pipe.

   See also Part B, Chapter 3.

c) Automatic closing appliances are to be of a type approved by the Society. Requirements for type tests are given in Ch 1, Sec 4, [6.2.2].

d) Where the tank venting system is not of an automatic type approved by the Society, provision is to be made for relieving vacuum when the tanks are being pumped out, and for this purpose a hole of about 10 mm in diameter in the bend of the air pipe, or at a suitable position in the closing device, is acceptable.

2.2.5 Exposed part of air pipes

Where air pipes extend above the freeboard deck or superstructure deck, the exposed parts of the pipes are to be of reinforced thickness in accordance with Ch 1, Sec 4, [2].

3 Sounding pipes

3.1 Sounding pipe arrangements

3.1.1 Principle

a) Sounding devices are to be fitted to tanks intended to contain liquids as well as to all compartments which are not readily accessible at all times.

b) For compartments normally intended to contain liquids, the following systems may be accepted in lieu of sounding pipes:
   - a level gauge of an approved type efficiently protected against shocks, or
   - a remote level gauging system of an approved type.

3.1.2 Position of sounding pipes

Sounding pipes are to be located as close as possible to suction pipes.

3.1.3 Termination of sounding pipes

a) As a general rule, sounding pipes are to end above the watertight deck or in such case above the bulkhead or the freeboard deck in easily accessible places and are to be fitted with efficient, permanently attached, metallic closing appliances.

b) In machinery spaces and tunnels, where the provisions of item a) cannot be satisfied, short sounding pipes led to readily accessible positions above the floor and fitted with efficient closing appliances may be accepted.

In yachts required to be fitted with a double bottom, such closing appliances are to be of the self-closing type.

3.1.4 Special arrangements for sounding pipes of flammable oil tanks

Where sounding pipes are used in flammable (except lubricating) oil systems, they are to terminate in the open air, where no risk of ignition of spillage from the sounding pipe might arise. In particular, they are not to terminate in passenger or crew spaces. As a general rule, they are not to terminate in machinery spaces. However, where the Society considers that this requirement is impracticable, it may permit termination in machinery spaces on condition that the sounding pipes terminate not close to source of ignition and are to be fitted with automatic closing appliance.

3.1.5 Closing appliances

a) Self-closing appliances are to be fitted with cylindrical plugs having counterweights such as to ensure automatic closing.

b) Closing appliances not required to be of the self-closing type may consist of a metallic screw cap secured to the pipe by means of a chain or a shut-off valve.

3.1.6 Construction of sounding pipes

a) Sounding pipes are normally to be straight. If it is necessary to provide bends in such pipes, the curvature is to be as small as possible to permit the ready passage of the sounding apparatus.

b) The internal diameter of sounding pipes is not to be less than 32 mm.

c) Doubling plates are to be placed under the lower ends of sounding pipes in order to prevent damage to the hull. When sounding pipes with closed lower ends are used, the closing plate is to have reinforced scantling.

4 Overflow pipes

4.1 Overflow pipe arrangements

4.1.1 Principle

Overflow pipes are to be fitted to tanks:

- which can be filled by pumping and are designed for a hydrostatic pressure lower than that corresponding to the height of the air pipe, or
- where the cross-sectional area of air pipes is less than that prescribed in [2.1.6].

4.1.2 Design of overflow systems

a) Overflow pipes are to be led:
   - either outside, or
   - in the case of fuel oil or lubricating oil, to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

b) Overflow pipes are to be led to a high enough point above the deepest load waterline or, alternatively, non-return valves are to fitted where necessary, to prevent any risk of flooding due to hull damage.

c) Arrangements are to be made so that a compartment cannot be flooded from the sea through the overflow in the event of another compartment connected to the same overflow main being flooded. To this end, the openings of overflow pipes discharging overboard are as a rule to be placed above the deepest load waterline and are to be fitted where necessary with non-return valves on the plating, or, alternatively, overflow pipes from tanks are to be led to a point above the deepest load waterline.

4.1.3 Overflow tanks

a) Overflow tanks are to be fitted with an air pipe complying with [2.2] which may serve as an overflow pipe for the same tank. When the vent pipe reaches a height exceeding the design head of the overflow tank, suitable means are to be provided to limit the actual hydrostatic head on the tank.

Such means are to discharge to a position which is safe in the opinion of the Society.

b) An alarm device is to be provided to give warning when the oil reaches a predetermined level in the tank, or alternatively, a sight-flow glass is to be provided in the overflow pipe to indicate when any tank is overflowing. Such sight-flow glasses are only to be placed on vertical pipes and in readily visible positions.

4.1.4 Specific arrangements for construction of overflow pipes

a) In each compartment which can be pumped up, the total cross-sectional area of overflow pipes is not to be less than 1,25 times the cross-sectional area of the corresponding filling pipes.

b) The cross-sectional area of the overflow main is not to be less than the aggregate cross-sectional area of the two largest pipes discharging into the main.

Section 8 Fuel Oil Systems

1 General

1.1 Applications

1.1.1 This Section applies to oil fuel systems for the service of propulsion engines and auxiliary machines.

1.1.2 For fuel oil systems supplying any other kind of installation, additional requirements not contained in this Section are given:
- for independent fuel oil tanks: in Pt B, Ch 7, Sec 5
- for fuel oil supply equipment forming part of engines, gas turbines and incinerators: in the corresponding sections
- for the location and scantling of tanks forming part of the yacht's structure: in Part B
- for helicopter refuelling facilities: in Ch 4, Sec 11, [4].

1.2 Principle

1.2.1 Fuel characteristics

Fuel oil systems are to be so designed as to ensure the proper characteristics (purity, viscosity, pressure) of the fuel oil supply to engines and boilers.

1.2.2 Design

Fuel oil systems are to be so designed as to prevent:
- overflow or spillage of fuel oil from tanks, pipes, fittings, etc.
- fuel oil from coming into contact with sources of ignition
- overheating and seizure of fuel oil.

1.2.3 Arrangement of fuel oil systems

a) For yachts where fuel oil is used, the arrangements for the storage, distribution and utilisation of the fuel oil are to be such as to ensure the safety of the yacht and persons on board.

b) The provisions of Ch 1, Sec 4, [5.13] are to be complied with.

1.3 General arrangements

1.3.1 Materials and details

Materials used for piping and equipment as well as general details are to be in compliance with Ch 1, Sec 4.

1.3.2 Alarms

Alarms, indicators and automatic controls of systems related to internal combustion engines are to be in compliance with Ch 1, Sec 2.

2 Oil fuel system design

2.1 Application

2.1.1 Scope

The following requirements apply to a motor or sailing yacht whatever are the length and gross tonnage.

2.1.2 Alternative arrangements for yacht having the navigation notation **sheltered area** or **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, or for sailing yacht may be agreed on a case by case basis.

2.1.3 Additional requirements

a) Additionally to this Article, the requirements of Article [3] apply to yachts and charter yachts over 24 m and less than 500 GT.

b) Additionally to this Article and to [3], the requirements of Article [4] apply to yachts and charter yachts over 500 GT.

2.2 General provisions

2.2.1 Definitions

Liquid fuels are classed in two categories:
- first category, liquid fuels of flash point less than 60°C (closed-cup test), hereafter designed as "gasoline"
- second category, liquid fuels of flash point equal or greater than 60°C (closed-cup test), hereafter designed as "diesel oil".

2.2.2 Arrangement

a) The entire oil fuel system is to be permanently installed.

b) Portable oil fuel tanks may be provided subject that they comply with requirements of [2.3].

c) Individual components of the system, as well as the whole system, are to be designed and installed to withstand the combined conditions of pressure, vibration and movement encountered under normal operating conditions.

d) When first category liquid fuel is used, metallic components of the system are to be grounded to the engine block. Electrical continuity is to be maintained from the deck fuel plate on the deck to the engine. Where non-conducting materials are used, a bonding conductor is to be installed across the break.

e) Oil components under pressure are to be so located that in the event of a leakage the fuel oil cannot be pulverised onto the exhaust manifold.

2.2.3 Passage through particular compartments

a) No fuel pipes are to pass through fresh water tanks and no fresh water pipes are to pass through fuel oil tanks.

b) No fuel pipes are to pass through accommodations.

c) Hot points and other sources of ignition, batteries, are to be kept clear from the vicinity of the oil fuel fittings, pumps and tanks.

2.2.4 Material

All materials used in the fabrication and installation of the tanks and component parts of the fuel system must be highly resistant to corrosion or degrading by the fuel for which the system is designed.

Cast metal fittings are to be pressure tested to a minimum pressure of 7 bars.

2.2.5 Provision to prevent overpressure

Provisions are to be made to prevent overpressure in any oil tank or in any part of the fuel oil system. Any relief valve is to discharge to a safe position.

2.2.6 Ventilation

The ventilation of machinery spaces is to be sufficient under all normal conditions to prevent accumulation of oil vapour.

2.2.7 Access

a) Spaces where fuel oil is stored or handled are to be readily accessible.

b) Oil fuel valves, filters, strainers, pumps and other similar fittings are to be readily accessible for inspection and maintenance.

2.2.8 Pumps controls

The power supply to oil fuel transfer pumps and to other pumps of the oil fuel system as well as to oil fuel separators is to be capable of being stopped from an always accessible place in the event of fire within the compartment where these equipment are located.

2.2.9 Drip-trays and gutterways

Drip-trays or gutterways with appropriate discharge devices are to be fitted, when necessary:

- under pumps, valves and filters
- under oil fuel tanks and bunkers which are not part of the yacht's structure, as well as
- under all the accessories subject to oil fuel leakage.

2.2.10 Provision to prevent risk of spillage

Provisions are to be taken to the Society's Surveyor satisfaction in order to minimize the risk of oil fuel spillage or leakage, and of accumulation of flammable vapours into the yacht.

2.3 Oil fuel tank and bunkers

2.3.1 General

a) First category liquid fuel tanks are not to be integral with the hull. They are to be located separately from the engine compartment.

b) If portable fuel tanks are used for first category liquid fuels, the tanks and their piping are to be type approved.

c) Engine mounted integral tanks for either first or second category liquid fuels may be used only for small engines of 4 kW maximum installed in open areas and having a maximum capacity of 10 litres.

d) Second category liquid fuel tanks may be integral with the hull. If reinforced plastic laminated core construction is used where the tank is integral with the hull, the core material is not to be deteriorated from contact with diesel fuel and is not to permit fuel to migrate.

2.3.2 Materials

a) Independent fuel oil tanks are to be made of steel material except when permitted in item b).

b) On yachts of less than 500 tons gross tonnage, independent fuel oil tanks may be made of:
   - copper, provided that copper tanks are tin coated internally when intended for first category fuel. They are not considered suitable for other liquid fuels
   - aluminium alloys or composite materials, provided that the tanks are located outside the propulsion machinery spaces or, when located within such spaces, they are fire insulated equivalent to steel or have a capacity of less than 100 l.

c) Steel tanks, when intended for first category liquid fuel, must be effectively protected internally and externally against corrosion. Where galvanising is used it must be by the hot dipped process. Sheet steel tanks intended for second category liquid fuel must not be galvanised internally.

2.3.3 Construction and design

a) The scantling of oil fuel bunkers and tanks forming part of the yacht's structure are to comply with the requirements stated in Part B.

b) Any metallic independent tank of a capacity more than 500 litres are to comply with the requirements of Pt B, Ch 7, Sec 5.

c) For metallic tanks all joints and seams must be either brazed, welded or equivalent.

d) Any oil fuel tank which length is more than 1000 mm is to be provided with suitable baffle plates.

e) For first category liquid fuel tanks, the following requirements are to be satisfied:
   - bottoms are not to have pockets that will accumulate water or sediment
   - the fill and outlet pipes are not extend to more than 50 mm of the bottom of the tank.

f) For second category liquid fuel tanks, the following requirements are to be satisfied:
   - as a rule, for capacities of more than 75 litres, a suitable handhole or similar opening is to be provided to facilitate internal inspection and cleaning
   - a sump or pocket in the tank bottom is to be provided for the collection of water, with drains fitted with self-closing valves or cocks.

2.3.4 Installation

a) Independent fuel tanks are to be permanently installed in such manner that they do not support decks, bulkheads or other structure. They are to be suitably supported and fixed.

b) Fuel tanks are to be sited in well-ventilated locations.

c) Location of oil fuel tanks and bunkers is to be chosen in a way to avoid any abnormal rise in temperature in these capacities.

d) The use of free standing oil fuel tanks is not permitted where spillage, leakage or vapour there from can constitute a hazard by falling on heated surfaces or where there is a risk of ignition.

2.3.5 Air and overflow pipes

Air and overflow pipes are to comply with Ch 1, Sec 7.

2.3.6 Level indicators

a) Safe and efficient means of ascertaining the amount of fuel oil contained in any fuel oil tank are to be provided.

   Means are to be such that, in the event of a tank being overfilled, spillage through them shall not occur.

b) Gauge cocks for checking the level in the tanks are not to be used.

c) Sounding pipes of fuel oil tanks are to comply with the provisions of Ch 1, Sec 7.

d) Oil-level gauges complying with Ch 1, Sec 7 may be used in place of sounding pipes.

   Where a level indicating gauge glass is fitted on a fuel tank, it is to be fitted with self-closing valves or cocks and made of heat resisting material. It is to be protected against shocks. Oil fuel tank soundings should not be located in crew accommodation.

e) Glass fuel level gauges fitted externally on the tanks are not to be used in first category liquid fuel systems.

2.3.7 Testing

All oil fuel independent type tanks are to be hydraulically tested prior to their installation inboard at a pressure of at least 0,24 bar for diesel oil and 0,36 bar for gasoline.

2.4 Filling, venting and transfer pipes

2.4.1 Oil fuel lines

a) The materials used are to be in accordance with Ch 1, Sec 4.

b) Fuel lines are to have a minimum of connections, all of which must be readily accessible.
   - Soft solder connection are not to be used.
   - Piping are to be connected by metal to metal joint of the conical type or by other approved type.

c) Filling, vent and transfer lines are to be made in fixed lines.

2.4.2 Fuel tanks filling system

a) All fuel tanks are to be fitted with a permanent filling pipe, of approved type led from the weather deck to the top of the tank. The minimum internal diameter of filling pipes is 38 mm. Suitable coamings and drains are to be provided to collect any leakage resulting from filling operations.

b) The deck filling plate is to be watertight designed and permanently stamped with a means of identifying the type of fuel the tank contains.

c) Separation between ventilation openings and fuel deck filling plate is to be at least 400 mm.

d) Refuelling instructions for first category liquid fuel should be permanently displayed in a position where they will be read by the operator. They should include warning against fire and explosion risks.

2.4.3 Fuel tanks venting system

a) All tanks are to be fitted with air vents ending outside the yacht.

b) Vent pipes must begin from the highest point of the tank and discharge in a position reasonably remote from ports, windows, or similar openings in the accommodation. They are to be arranged to prevent the accidental entry of water.

c) In first category liquid fuel installations, pipes must be fitted with an approved flame screen at the outlet, having an effective area not less than the minimum required for the vent pipe. It must be arranged to permit easy cleaning.

d) For tanks of less than 30 litres capacity, separate vent pipes may be dispensed if the filling pipe is suitably arranged.

e) For normal hose filling, inside diameter of the vent pipe is to be 14 mm at least.

When filling can be carried out under pressure (with airtight coupling), a special examination of the Society can be carried out.

2.4.4 Transfer system

If main propulsion is ensured by engines and if transfer circuit of fuel liquid exists, this transfer is to be ensured by two pumps. One of these pumps may be manual.

2.5 Oil fuel tanks and bunkers

2.5.1 Filling and suction pipes

a) all suction pipes from fuel oil tanks and bunkers, including those in the double bottom, are to be provided with valves

b) for storage tanks, filling pipes may also be used for suction purposes

c) for fuel oil tanks which are situated higher than the double bottom tanks, the filling pipes which are connected to the tank at a point lower than the outlet of the overflow pipe, or below the top of tanks without an overflow pipe, are to be fitted with shut-off non-return valves, unless they are fitted with valves arranged in accordance with the requirements stated in [2.5.2]. For filling lines entering at the top of a tank and with inside extension towards the bottom, airholes shall be drilled in the pipe near the penetration in order to avoid the siphoning effect

d) for oil piping which is led through engine room bulkheads, shut-off valves are to be fitted in the engine room on the bulkhead, or close to, except where it is demonstrated that possible failure of the piping would not affect the availability of the fuel oil system or the safety of engine room, in general

e) the valves requested in items a), c) and d) shall be located on the tank or bulkhead itself. However, short distance pieces of rigid construction may be accepted, the length of which is not to exceed about 1,5 D of the pipe.

2.5.2 Remote control of valves

a) every fuel oil pipe which, if damaged, would allow oil to escape from a storage, settling or daily service tank having a capacity of 500 l and above situated above the double bottom, is to be fitted with a cock or valve directly on the tank capable of being closed from a safe position outside the space in which such tanks are situated in the event of a fire occurring in such space

b) such valves and cocks are also to include local control. Indicators are to be provided on the remote and local controls to show whether they are open or shut. Where quick-closing valves are used, the indicators for remote controls may be omitted

c) where fuel oil tanks are situated outside boiler and machinery spaces, the remote control required in item a) may be transferred to a valve located inside the boiler or machinery spaces on the suction pipes from these tanks

d) in the special case of deep tanks situated in any shaft or pipe tunnel or similar space, valves are to be fitted on the tank but control in the event of fire may be effected by means of an additional valve on the pipe or pipes outside the tunnel or similar space. If such additional valve is fitted in the machinery space it is to be operated from a position outside this space.

Note 1: Where the fuel oil transfer installation is designed for manual operation, suction valves from fuel oil tanks and bunkers, with the exception of daily service tanks, need not be arranged with remote controls provided they are maintained closed except during transfer operations. Such valves are, however, to be readily accessible and instruction plates are to be fitted in their vicinity specifying that they are to be kept closed except during transfer operations.

2.5.3 Drains

Daily service tanks are to be provided with drains permitting the evacuation of water and impurities likely to accumulate in the lower part of these tanks.

These drains are to be fitted with self-closing valves or cocks.

2.6 Oil fuel supply to engines

2.6.1 Suctions

The suctions of engine fuel pumps are to be so arranged as to prevent the suction of gathered water and sludge likely to accumulate after decanting at the lower part of service tanks.

2.6.2 Filters

a) Internal combustion engines intended for main propulsion with an output of more than 375 kW are to be fitted with at least two filters, or similar devices, so arranged that one of the filters can be overhauled while the other is in use.

   In case of two independent propulsion lines, one filter only for each engine could be accepted if it is demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring on one propulsion line.

b) Fuel filters are to be made of material highly resistant to mechanical impacts and thermal shocks.

c) Fuel filters must be fitted with drain plugs.

d) Filters must be tested to 2 bars or 1,5 times the design pressure, whichever is the greater.

2.6.3 Pumps

a) In first category liquid fuel system, gravity feed systems is to be permitted only for small engines with a tank capacity not exceeding 10 litres.

b) When an fuel oil booster pump is fitted which is essential to the operation of the main engine with an output of more than 375 kW, a stand-by pump, connected ready for immediate use, is to be provided.

   This pump could be omitted in case of two independent propulsion lines in which each engine is fitted with its own booster pump and it is demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring on one propulsion line.

c) Excess fuel oil from pumps or injectors is to be led back to the service or settling tanks, or to other tanks intended for this purpose.

2.6.4 High pressure fuel oil pipes

See Ch 1, Sec 2, [2.2.8].

2.7 Control and monitoring

2.7.1 Monitoring

Fuel oil systems are to be fitted with the following alarms:

a) when fuel oil overflow tank is fitted, a high level alarm or a sightglass is to be fitted

b) daily service tank is to be fitted with a low level alarm with a local indication or a sightglass.

2.7.2 Remote controls

a) The remote control arrangement of valves fitted on fuel oil tanks is to comply with [2.5.2].

b) The positions of the remote controls are also to comply with Part C, Chapter 3.

3 Yacht or charter yacht equal to or over 24 m and less than 500 GT

3.1 Application

3.1.1 Scope

The following requirements apply to motor or sailing yacht of 24 metres in load line length and over, and of less than 500 tons gross tonnage.

In addition, the requirements of [3] are to be complied with.

3.1.2 Alternative arrangements for yacht having the navigation notation **sheltered area** or **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, or for sailing yacht may be agreed on a case by case basis.

3.2 Principles

3.2.1 General

The use for propulsion engines and auxiliary machine of oil fuel having a flash point lower than 60°C is subject to a special examination by the Society.

3.2.2 Fuel oil tanks

Fuel oil tanks are to be so arranged that, in the event of damage to any one tank, complete loss of the fuel supply to essential services does not occur.

Note 1: The present rule needs not to be complied with if the single tank is duly protected against the ingress of water either by mechanical protection of the airpipe or by watertraps.

4 Yacht or charter yacht over 500 GT

4.1 Application

4.1.1 Scope

The following requirements apply to motor or sailing yacht of 500 tons gross tonnage and over.

In addition, the requirements of [3] are to be complied with.

4.1.2 Alternative arrangements for yacht having the navigation notation **sheltered area** or **coastal area** as defined in Pt A, Ch 1, Sec 2, or for sailing yacht may be agreed on a case by case basis.

4.2 Arrangement of fuel oil tanks and bunkers

4.2.1 Location of fuel oil tanks

a) No fuel oil tank is to be situated where spillage or leakage there from can constitute a hazard by falling on heated surfaces.

b) As far as practicable, fuel oil tanks are to be part of the yacht's structure and are to be located outside machinery spaces of category A. Where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of category A, at least one of their vertical sides is to be contiguous to the machinery space boundaries, and is preferably to have a common boundary with the double bottom tanks, and the area of the tank boundary common with the machinery spaces is to be kept to a minimum. Where such tanks are situated within the boundaries of machinery spaces of category A, they are not to contain fuel oil having a flash point of less than 60°C.

Note 1: Machinery spaces of category A are defined in Ch 4, Sec 1.

4.3 Design of fuel supply systems

4.3.1 Fuel oil tanks

Two fuel oil service tanks used on board necessary for propulsion and essential systems, or equivalent arrangements, are to be provided. The capacity of each one of these tanks is to be at least 8 h, enabling safe operation of the ship.

4.3.2 Fuel oil supply to internal combustion engines

In multi-engine installations which are supplied from the same fuel source, means of isolating the fuel supply and spill piping to individual engines are to be provided. The means of isolation are not to affect the operation of the other engines and are to be operable from a position not rendered inaccessible by a fire on any of the engines.

Section 9 Other Systems

1 General

1.1 Application

1.1.1 This Article concerns the following systems:

- cooling systems
- ballast systems
- lubrication oil systems
- hydraulic systems
- compressed air systems
- exhaust gas systems
- ventilation systems.

1.2 General arrangements

1.2.1 Materials and details

Materials used for piping and equipment as well as general details are to be in compliance with Ch 1, Sec 4.

1.2.2 Alarms

Alarms, indicators and automatic controls of systems related to internal combustion engines are to be in compliance with Ch 1, Sec 2.

2 Cooling systems

2.1 Application

2.1.1 This Article applies to all cooling systems using the following cooling media:

- sea water
- fresh water.

Air cooling systems will be given special consideration.

2.2 Principle

2.2.1 General

Sea water and fresh water cooling systems are to be so arranged as to maintain the temperature of the cooled media (lubricating oil, hydraulic oil, charge air, etc.) for propulsion machinery and essential equipment within the manufacturers' recommended limits during all operations, including starting and manoeuvring, under the inclination angles and the ambient conditions specified in Ch 1, Sec 1.

2.3 Design of sea water cooling systems

2.3.1 General

a) Sea water cooling of the propulsion engines, auxiliary engines and other essential equipment is to be capable of being supplied by two different means.

b) Where required, stand-by pumps are not to be connected to the sea inlet serving the other sea water pumps, unless the two sea inlets are connected by a cross-over.

2.3.2 Number of pumps

a) Cooling systems of propulsion engines with an output of more than 375kW are to include at least:
   - one main cooling water pump, which can be driven by the engine
   - one independently driven stand-by pump of at least the same capacity.

b) A general service pump of sufficient capacity can be used as stand-by pumps.

c) In yachts having two or more propulsion engines, each with its own cooling pump, the independent stand-by pump may be omitted if it is demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring on one propulsion line.

2.4 Design of fresh water cooling systems

2.4.1 General

a) Fresh water cooling systems are to be designed according to the applicable requirements of [2.3].

b) Where the engines are cooled by fresh water, the second means stated in [2.3.2] item a) may be omitted if a connection is fitted from the fresh water system to a suitable sea water system.

2.4.2 Expansion tanks

Fresh water expansion tanks are to be provided with at least:

- a de-aerating device
- a water level indicator
- a filling connection
- a drain.

2.5 Arrangement of cooling systems

2.5.1 Sea inlets

a) Not less than two sea inlets are to be provided for the engine cooling system. These sea inlets are to be distinct for the two means of cooling given in [2.3.2] item a), but they may be cross connected by a cross pipe.

b) In yachts having two or more propulsion engines, each with its own sea inlet, the second sea inlet may be omitted if it is demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring on one propulsion line.

c) These sea inlets are to be low inlets and one of them may be that of the ballast pump or of the general service pump. A sea inlet is considered as low provided it remains submerged under all normal navigating conditions.

2.5.2 Coolers

a) Coolers are to be fitted with isolating valves at the inlets and outlets.

b) Coolers external to the hull (chest coolers and keel coolers) are to be fitted with isolating valves at the shell.

2.5.3 Filters

a) Where propulsion engines and auxiliary engines for essential services are directly cooled by sea water, both in normal service and in emergency operating conditions, filters are to be fitted on the suction of cooling pumps.

b) When the output of the engine exceeds 375 kW, these filters are to be so arranged that they can be cleaned without interrupting the cooling water supply.

2.5.4 Pumps

a) When redundancy of pumps is not required, the pump connected to the cooling systems may be either independent or driven by the machine it serves.

b) Relief valves are to be fitted on the discharge of cooling pumps driven by main engines, except for centrifugal type pumps.

3 Ballast systems

3.1 Applications

3.1.1 Scope

This Article applies to ballast systems fitted on every type of yachts.

3.2 Design of ballast systems

3.2.1 Independence of ballast lines

Ballast lines are to be entirely independent and distinct from lines conveying lubricating oil and fuel oil.

3.2.2 Prevention of undesirable communication between spaces or with the sea

Ballast systems in connection with bilge systems are to be so designed as to avoid any risk of undesirable communication between spaces or with the sea.

3.2.3 Bilge and ballast systems

The arrangement of the bilge and ballast pumping system are to be such as to prevent the possibility of water passing from the sea and from water ballast spaces into machinery spaces, or from one compartment to another.

3.2.4 Alternative carriage

Alternative carriage of fuel oil, feed water and ballast water in the same tanks is not permitted.

3.3 Ballast pumping arrangement

3.3.1 Filling and suction pipes

a) All tanks including aft and fore peak and double bottom tanks intended for ballast water are to be provided with suitable filling and suction pipes connected to a power driven pump of adequate capacity.

b) Suctions are to be so positioned that the transfer of sea water can be suitably carried out in the normal operating conditions of the yacht.

3.3.2 Pumps

a) Bilge pumps may be used for ballast water transfer provided the provisions of Ch 1, Sec 5, [3.3.4] are fulfilled.

b) Small tanks may be served by hand pumps.

4 Lubricating oil systems

4.1 Application

4.1.1 This Article applies to lubricating oil systems serving diesel engines, reduction gears, clutches and controllable pitch propellers, for lubrication or control purposes.

4.2 Principle

4.2.1 General

a) Lubricating oil systems are to be so designed as to ensure reliable lubrication of the engines and other equipment intended for propulsion:
   - over the whole speed range, including starting, stopping and, where applicable, manoeuvring
   - for all the inclinations angles stated in Ch 1, Sec 1.

b) Lubricating oil systems are to be so designed as to ensure sufficient heat transfer and appropriate filtration of the oil.

c) Lubricating oil systems are to be so designed as to prevent oil from entering into contact with sources of ignition.

d) Lubricating oil pipes are to be independent of any other fluid system.

4.2.2 Arrangement of lubricating oil systems

a) The arrangements for the storage, distribution and utilisation of oil used in pressure lubrication systems are to be such as to ensure the safety of the yacht and persons on board and to minimise the risk of fire or explosion.

b) The provisions of Ch 1, Sec 4, [5.13] are to be complied with, where applicable.

4.2.3 Filtration

a) In forced lubrication systems, a device is to be fitted which efficiently filters the lubricating oil in the circuit.

b) The filters provided for this purpose for main machinery and machinery driving electric propulsion generators are to be so arranged that they can be easily cleaned without stopping the lubrication of the machines.

c) The fineness of the filter mesh is to comply with the requirements of the engine or turbine manufacturers.

d) Where filters are fitted on the discharge side of lubricating oil pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

4.3 Design of oil lubrication and oil control systems

4.3.1 Lubrication of propulsion engines

a) Main engines with an output of more than 375 kW are to be provided with at least two power lubricating pumps, of such a capacity as to maintain normal lubrication with any one pump out of action.

b) In yachts having two or more propulsion engines, each with its own lubricating pump, the second pump may be omitted if it is demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring on one propulsion line.

4.3.2 Lubrication of auxiliary engines

a) For auxiliary engines with their own lubricating pump, no additional pump is required.

b) For auxiliary engines with a common lubricating system, at least two pumps are to be provided. However, when such engines are intended for non-essential services, no additional pump is required.

4.4 Design of lubricating oil tanks

4.4.1 Remote control of valves

Lubricating oil tanks are to be fitted with remote controlled valves in accordance with the provisions of Ch 1, Sec 8, [2.5.2].

The remote controlled valves need not be arranged for storage tanks on which valves are normally closed except during transfer operation, or where it is determined that an unintended operation of a quick closing valve on the oil lubricating tank would endanger the safe operation of the main propulsion and essential auxiliary machinery.

4.4.2 Filling and suction pipes

Filling and suction pipes are to comply with the provisions of Ch 1, Sec 8, [2.5.1].

4.4.3 Air and overflow pipes

Air and overflow pipes are to comply with the provisions of Ch 1, Sec 7.

4.4.4 Sounding pipes and level gauges

a) Safe and efficient means of ascertaining the amount of lubricating oil contained in the tanks are to be provided.

b) Sounding pipes are to comply with the provisions of Ch 1, Sec 7.

c) Oil-level gauges complying with Ch 1, Sec 4 may be used in place of sounding pipes.

d) Gauge cocks for ascertaining the level in the tanks are not to be used.

4.5 Control and monitoring

4.5.1 Alarms

In addition to the requirements in Ch 1, Sec 2 for diesel engines and gears, the following alarms are to be provided:

- a high level alarm, when the lubricating oil tank is fitted with an air pipe water trap
- a local level indication, when a sludge tank is provided.

4.5.2 Safety devices

Lubricating oil systems for propulsive engines are to be provided with an alarm device giving audible warning in the event of an appreciable reduction of the oil pressure.

4.6 Construction of lubricating oil piping systems

4.6.1 Sight-flow glasses

The use of sight-flow glasses in lubricating systems is permitted, provided that they are shown by testing to have a suitable degree of fire resistance.

5 Hydraulic systems

5.1 Application

5.1.1 Hydraulic installations intended for essential services

Unless otherwise specified, this Article applies to all hydraulic power installations intended for essential services.

5.1.2 Hydraulic installations located in spaces containing sources of ignition

Hydraulic power installations not serving essential services but located in spaces where sources of ignition are present are to comply with the provisions of [5.3.2] to [5.4.5].

5.1.3 Hydraulic installations intended for steering gear

Additionally to this Article, hydraulic installations intended for steering gear are to comply with the relevant provisions of Ch 1, Sec 3.

5.1.4 Low pressure or low power hydraulic installations

Hydraulic power installations with a design pressure of less than 2,5 MPa and hydraulic power packs of less than 5 kW will be given special consideration by the Society.

5.1.5 Very high pressure hydraulic installations

Hydraulic power installations with a design pressure exceeding 35 MPa will be given special consideration by the Society.

5.2 General

5.2.1 Design requirements

As far as practicable, hydraulic systems are to be so designed as to:

- avoid any overload of the system
- maintain the actuated equipment in the requested position (or the driven equipment at the requested speed)
- avoid overheating of the hydraulic oil
- prevent hydraulic oil from coming into contact with sources of ignition.

5.2.2 Availability

a) As a rule, hydraulic systems are to be so designed that, in the event that any one essential component becomes inoperative, the hydraulic power supply to essential services can be maintained. Partial reduction of the propulsion capability may be accepted, however, when it is demonstrated that the safe operation of the yacht is not impaired.

b) When a hydraulic power system is simultaneously serving one essential system and other systems, it is to be ensured that:
   - operation of such other systems, or
   - a single failure in the installation external to the essential system,

   is not detrimental to the operation of the essential system.

c) Provision b) applies in particular to steering gear.

d) Hydraulic systems serving lifting or hoisting appliances, including platforms, ramps, hatch covers, lifts, etc., are to be so designed that a single failure of any component of the system may not result in a sudden undue displacement of the load or in any other situation detrimental to the safety of the yacht and persons on board.

5.3 General

5.3.1 Definitions

a) A power unit is the assembly formed by the hydraulic pump and its driving motor.

b) An actuator is a component which directly converts hydraulic pressure into mechanical action.

5.3.2 Limitations of use of hydraulic oils

a) Oils used for hydraulic power installations are to have a flash point not lower than 150°C and be suitable for the entire service temperature range.

b) The hydraulic oil is to be replaced in accordance with the specification of the installation manufacturer.

5.3.3 Location of hydraulic power units

a) Whenever practicable, hydraulic power units are to be located outside main engine rooms.

b) Where this requirement is not complied with, shields or similar devices are to be provided around the units in order to avoid an accidental oil spray or jet on heated surfaces which may ignite oil.

5.4 Design of hydraulic pumps and accessories

5.4.1 Power units

a) Hydraulic power installations are to include at least two power units so designed that the services supplied by the hydraulic power installation can operate simultaneously with one power unit out of service. A reduction of the performance may be accepted.

b) Power hydraulic installations not supplying essential services may be fitted with a single power unit, provided that alternative means, such as a hand pump, are available on board.

c) Low power hydraulic installations not supplying essential services may be fitted with a single power unit.

5.4.2 Pressure reduction units

Pressure reduction units used in hydraulic power installations are to be duplicated.

5.4.3 Filtering equipment

a) A device is to be fitted which efficiently filters the hydraulic oil in the circuit.

b) Where filters are fitted on the discharge side of hydraulic pumps, a relief valve leading back to the suction or to any other convenient place is to be provided on the discharge of the pumps.

5.4.4 Provision for cooling

Where necessary, appropriate cooling devices are to be provided.

5.4.5 Provision against overpressure

a) Safety valves of sufficient capacity are to be provided at the high pressure side of the installation.

b) Safety valves are to discharge to the low pressure side of the installation or to the service tank.

5.4.6 Provision for venting

Cocks are to be provided in suitable positions to vent the air from the circuit.

5.4.7 Provision for drainage

Provisions are to be made to allow the drainage of the hydraulic oil contained in the installation to a suitable collecting tank.

5.5 Design of hydraulic tanks and other components

5.5.1 Hydraulic oil service tanks

a) Service tanks intended for hydraulic power installations supplying essential services are to be provided with at least:
   - a level gauge complying with Ch 1, Sec 4
   - a temperature indicator
   - a level switch complying with [5.6.2].

b) The free volume in the service tank is to be at least 10% of the tank capacity.

5.5.2 Hydraulic oil storage tanks

a) Hydraulic power installations supplying essential services are to include a storage tank of sufficient capacity to refill the whole installation should the need arise case of necessity.

b) For hydraulic power installations of less than 5 kW, the storage means may consist of sealed drums or tins stored in satisfactory conditions.

5.5.3 Hydraulic accumulators

The hydraulic side of the accumulators which can be isolated is to be provided with a relief valve or another device offering equivalent protection in case of overpressure.

5.6 Control and monitoring

5.6.1 Indicators

Arrangements are to be made for connecting a pressure gauge where necessary in the piping system.

5.6.2 Monitoring

Alarms and safeguards for hydraulic power installations intended for essential services, except steering gear, for which the provisions of Ch 1, Sec 3 apply, are to be provided with the following:
- low pump pressure alarm
- low service tank level.

6 Compressed air systems

6.1 Application

6.1.1 This Article applies to compressed air systems intended for essential services, and in particular to:
- starting of engines
- control and monitoring
- air whistle.

6.2 Principle

6.2.1 General

a) As a rule, compressed air systems are to be so designed that the compressed air delivered to the consumers:
   - is free from oil and water, as necessary
   - does not have an excessive temperature.

b) Compressed air systems are to be so designed as to prevent overpressure in any part of the systems.

c) Compressed air receivers are to comply with the requirements of NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 3, regarding pressure vessels.

6.2.2 Availability

a) Compressed air systems are to be so designed that, in the event of failure of one air compressor or one air receiver intended for starting, control purposes or other essential services, the air supply to such services can be maintained.

b) The compressed air system for starting main engines and auxiliary engines for essential services is to be so arranged that it is possible to ensure the initial charge of air receiver(s) without the aid of a power source outside the yacht.

6.3 Design of starting air systems

6.3.1 Initial charge of starting air receivers

a) Where, for the purpose of [6.2.2], an emergency air compressor is fitted, its driving engine is to be capable of being started by hand-operated devices. Independent electrical starting batteries may also be accepted.

b) A hand compressor may be used for the purpose of [6.2.2] only if it is capable of charging within one hour an air receiver of sufficient capacity to provide 3 consecutive starts of a propulsion engine or of an engine capable of supplying the energy required for operating one of the main compressors.

6.3.2 Number and capacity of air compressors

Where main and auxiliary engines are arranged for starting by compressed air, an air compressor is to be fitted with a capacity sufficient to supply within one hour the quantity of air needed to satisfy the following provisions:

a) The total capacity of the compressed air available for starting purpose is to be sufficient to provide, without replenishment, not less than 12 consecutive starts alternating between ahead and astern of each main engine of the reversible type, and not less than 6 consecutive starts of each main non-reversible type engine connected to a controllable pitch propeller or other device enabling the start without opposite torque.

   The number of starts refers to the engine in cold and ready-to-start condition (all the driven equipment that cannot be disconnected is to be taken into account).

   A greater number of starts may be required when the engine is in warm running condition.

   At least 3 consecutive starts is to be possible for each engine driving electric generators and engines for other purposes. The capacity of a starting system serving two or more of the above specified purposes is to be the sum of the capacity requirements.

   The capacity of a starting system serving two or more of the above specified purposes is to be the sum of the capacity requirements.

b) For multi-engine propulsion plants, the capacity of the starting air receivers is to be sufficient to ensure at least 3 consecutive starts per engine. However, the total capacity is not to be less than 12 starts and need not exceed 18 starts.

6.3.3 Number and capacity of air receivers

Where main engines are arranged for starting by compressed air, at least one air receiver is to be fitted with a capacity sufficient to provide without replenishment the number of starts required in [6.3.2]. It is also to take into account the air delivery to other consumers, such as control systems, whistle, etc., which are connected to the air receiver.

Yachts with **unrestricted navigation** notation shall be fitted with at least two air receivers, each one of them having the capacity mentioned above.

6.3.4 Air supply for starting the emergency generating set

Where starting air arrangement is one of two independent means of starting required in NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 2, [3.1.3] for the emergency generator, the following is to be complied with:

a) The starting air arrangement is to include a compressed air vessel, storing the energy dedicated only for starting of the emergency generator. The capacity of the compressed air available for starting purpose is to be sufficient to provide, without replenishment, at least three consecutive starts

b) The compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a non-return valve fitted in the emergency generator space, or by an emergency air compressor which, if electrically driven, is supplied from the emergency switchboard

c) All of these starting, charging and energy storing devices are to be located in the emergency generator space and is not to be used for any purpose other than the operation of the emergency generating set.

6.4 Design of control and monitoring air systems

6.4.1 Air supply

a) At least one air vessel fitted with a non-return valve is to be provided for control and monitoring purposes.

b) Failure of the control air supply is not to cause any sudden change of the controlled equipment which may be detrimental to the safety of the yacht.

c) when a pressure reducing valve is fitted then requirements of Ch 1, Sec 4, [1.3.2], item c) apply

d) pressure reduction units used in control and monitoring air system intended for essential services are to be duplicated unless alternative means is provided to keep the essential services operable

e) if only one air vessel is fitted on the air system supplying the air whistle, then an electrical air whistle is to be added.

6.4.2 Pressure control

Arrangements are to be made to maintain the air pressure at a suitable value in order to ensure satisfactory operation of the installation.

6.4.3 Air treatment

In addition to the provisions of [6.7.3], arrangements are to be made to ensure cooling, filtering and drying of the air prior to its introduction in the monitoring and control circuits.

6.5 Design of air compressor

6.5.1 Prevention of overpressure

a) Air compressor is to be fitted with a relief valve complying with Ch 1, Sec 4, [5.2.3].

b) Means are to be provided to prevent overpressure wherever water jackets or casings of air compressors may be subjected to dangerous overpressure due to leakage from air pressure parts.

c) Water space casings of intermediate cooler of air compressor are to be protected against any overpressure which might occur in the event of rupture of air cooler tubes.

6.5.2 Provision for draining

Air compressors are to be fitted with a drain valve.

6.6 Control and monitoring of compressed air systems

6.6.1 Monitoring

Alarms and safeguards are to be provided for compressed air systems with the following:

- low and high air pressure alarm after reducing valves
- low and high air vessel pressure.

6.6.2 Automatic controls

Automatic pressure control is to be provided for maintaining the air pressure in the air receivers within the required limits.

6.7 Arrangement of compressed air piping systems

6.7.1 Prevention of overpressure

Suitable pressure relief arrangements are to be provided for all systems.

6.7.2 Air supply to compressors

a) Provisions are to be made to reduce to a minimum the entry of oil into air pressure systems.

b) Air compressor is to be located in spaces provided with sufficient ventilation.

6.7.3 Air treatment and draining

a) Provisions are be made to drain air pressure systems.

b) Efficient oil and water separators, or filters, are to be provided on the discharge of compressors, and drains are to be installed on compressed air pipes wherever deemed necessary.

6.7.4 Lines between compressors, receivers and engines

All discharge pipes from starting air compressors are to be lead directly to the starting air receivers, and all starting pipes from the air receivers to main or auxiliary engines are to be entirely separate from the compressor discharge pipe system.

6.7.5 Protective devices for starting air mains

Non-return valves and other safety devices are to be provided on the starting air mains of each engine in accordance with the following provisions:

The main starting air arrangements for main propulsion or auxiliary diesel engines are to be adequately protected against the effects of backfiring and internal explosion in the starting air pipes. To this end, the following safety devices are to be fitted:

- an isolating non-return valve, or equivalent, at the starting air supply connection to each engine
- a bursting disc or flame arrester:
  - in way of the starting valve of each cylinder, for direct reversing engines having a main starting air manifold
  - at least at the supply inlet at the starting air manifold, for non-reversing engines.

The bursting disc or flame arrester above may be omitted for engines having a bore not exceeding 230 mm.

Other protective devices are to be specially considered by the Society.

Note 1: The present [6.7.5] does not apply to engines started by pneumatic motors.

7 Exhaust gas systems

7.1 General

7.1.1 Application

This Article applies to exhaust gas pipes from engines and smoke ducts from incinerators.

7.1.2 Principle

Exhaust gas systems are to be so designed as to:

- limit the risk of fire
- prevent gases from entering manned spaces
- prevent water from entering engines.

7.2 Design of exhaust systems

7.2.1 General

a) Exhaust systems are to be so arranged as to minimise the intake of exhaust gases into manned spaces, air conditioning systems and engine intakes.

b) The exhaust system is to be gas-tight throughout its passage inside the yacht.

c) When piping is led through an accommodation, locker or similar compartment, it is to be of thick, corrosion resistant material, adequately insulated or to be routed in a gas-tight casing.

7.2.2 Limitation of exhaust line surface temperature

a) Exhaust gas pipes and silencers are to be either water cooled or efficiently insulated where:
   - their surface temperature may exceed 220°C, or
   - they pass through spaces of the yacht where a temperature rise may be dangerous.

b) The insulation of exhaust systems is to comply with the provisions of Ch 1, Sec 1, [3.7.1].

c) If not oil-proof, the insulating material may be covered with an oil-proof material. If foamed plastic is used, it must be of a closed-cell type, resistant to oil, grease and be fire-resistant.

7.2.3 Limitation of pressure losses

Exhaust gas systems are to be so designed that pressure losses in the exhaust lines do not exceed the maximum values permitted by the engine manufacturer.

7.2.4 Intercommunication of engine exhaust gas lines

Exhaust pipes of several engines are not to be connected together but are to be run separately to the atmosphere unless arranged to prevent the return of gases to an idle engine.

7.2.5 Hull integrity

a) The general requirements indicated in Part B, Chapter 2 are also valid for the present requirement.

b) Where exhaust pipes are led overboard, means are to be provided to prevent water from entering the engine or the yacht. The pipes are to be looped or fitted with a suitable device such as a riser to prevent the return of water to the engine.

c) Where a shut-off valve is fitted at the overboard discharge, means are to be provided to prevent the engine from being started when the valve is not fully open.

   Moreover this valve is to be readily operable from an accessible position.

d) Outlet is to be fitted, where necessary, with a cowl or other suitable means which prevents the ingress of rain or snow.

7.2.6 Control and monitoring

When water-cooled exhaust gas pipes are used, a high temperature alarm must be fitted after the water injection device. Alternatively, an alarm of low sea water flow rate may be fitted.

7.3 Arrangement of exhaust piping systems

7.3.1 Provision for thermal expansion

a) Exhaust pipes and smoke ducts are to be so designed that any expansion or contraction does not cause abnormal stresses in the piping system, and in particular in the connection with engine turboblowers.

b) The devices used for supporting the pipes are to allow their expansion or contraction.

7.3.2 Provision for draining

a) Drains are to be provided where necessary in exhaust systems in order to prevent water flowing into the engine.

b) Where exhaust pipes are water cooled, they are to be so arranged as to be self-draining overboard.

7.3.3 Silencers

Engine silencers are to be so arranged as to provide easy access for cleaning and overhaul.

8 Ventilation

8.1 General

8.1.1 Application

This Article applies to ventilation system of spaces containing propulsion engines or flammable products.

8.1.2 Principle

Adequate ventilation is to be provided for spaces containing engines or other heat generating apparatuses, as well as for spaces where flammable vapours are likely to accumulate.

8.2 Design of ventilation systems

8.2.1 Ventilation capacity

Except where the machinery or fuel tank spaces are of open type, they are to be provided with the necessary ventilation in accordance with the engine's air consumption and heat emission as specified by the engine manufacturer and the necessary ventilation to prevent the accumulation of oil flammable or explosive vapors.

8.2.2 Open type space definition

A space may be considered as of open type when it complies with the following conditions:

- space is located above the weather deck with openings at the top and the bottom
- space has at least 0,35 m^2 of area exposed to the atmosphere per cubic meter of its net volume provided that no long or narrow unvented spaces remain inside in which a flame front might propagate.

8.3 Arrangement of ventilation systems

8.3.1 Ventilation type

Natural or mechanical ventilation are acceptable.

8.3.2 Operating conditions

The ventilation is to be capable of operating with all access openings closed.

8.3.3 Exterior intake and outlet arrangement

Air intakes and air outlets are to be so arranged and located to prevent re-entry of exhausted fumes. They are to be located 40 cm from the gasoline fill and vent fittings.

8.3.4 Interior air intake and outlet arrangement

The inlet air ventilation is to be located as far as practicable at the forward end of the space which is to be ventilated and led down to within the lowest part. The outlet is to be fitted at the opposite, as far as practicable, at the top of the space and terminated at the open air.

8.3.5 Ventilation outlet

a) Where cowls or scoops are provided on any ventilation duct, the free area of the cowl or scoop is not to be less than twice the duct area. Where the cowls or scoops are screened, the mouth area is to be increased to compensate for the area of the screen wire.

b) Outlet ventilation ducts are not to discharge within one metre of possible source of ignition.

c) Precautions are to be taken to prevent recycling.

8.3.6 Fire protection

a) The means of closing of ventilation openings in case of fire are to meet the requirements stated in Part C, Chapter 4.

b) Mechanical ventilating fans are to be capable of being stopped from outside the space supplied by these ventilating fans.

8.3.7 Hull integrity

The provisions of Pt B, Ch 2, Sec 2 are to be complied with concerning:

- height of ventilation coamings
- closing appliances.

8.4 Gas consuming appliances

8.4.1 Arrangement

a) Spaces containing a gas consuming appliance are to be provided with high and low ventilation openings.

b) Natural or mechanical ventilation are acceptable.

c) Where mechanical ventilation is fitted to any space in which gas containers or gas consuming appliances are situated, the material and design of the fan are to be such as to eliminate incendive sparking due to friction or impact of the fan impeller with the casing. Electric motors driving fans are to be situated outside the space, outside the ventilation trunking and clear of outlets. Alternatively suitably certified flameproof motors may be used if this cannot be achieved. Ventilation outlets are to be in a safe area free from ignition hazard. Mechanical exhaust ventilation trunking are to be led down to The lower part of the space and adjacent to the appliance.

d) Any gas-consuming appliance is to be so located in relation to the ventilation system that air flow would not extinguish the gas flames.

8.5 First category fuel installation

8.5.1 Scope

This sub-article apply to installation using first category fuel, i.e fuel having a flashpoint less than 60°C, additionally to the requirements of [8.3].

8.5.2 General

a) Except for spaces open to the atmosphere, a natural ventilation system is to be provided for:
   - engine space
   - spaces which contain a permanently installed fuel tank or a portable fuel tank that vents into the space
   - enclosed spaces in direct connection with spaces for engines or fuel tank.

b) Except for spaces open to the atmosphere a mechanical ventilation complying with [8.5.4] is to be provided for each space with a permanently installed first category fuel engine in addition to the natural ventilation.

c) Accommodation, machinery and fuel tank spaces are to be separated from each other with gastight subdivision to prevent the circulation of explosive vapors throughout the yacht.

8.5.3 Natural ventilation

a) Each natural ventilation system is to include at least one intake and one exhaust opening.

b) Exhaust ducts and intake ducts are to be located in accordance with [8.3.4].

c) The cross-sectional area of exhaust, intake ducts or openings, are to be sufficient to supply necessary ventilation in accordance with the engine's air consumption and heat emission as specified by the engine manufacturer and the necessary ventilation to prevent the accumulation of oil flammable or explosive vapors.

d) Increased air intake area may be required for space of a complicated shape after consideration by the Society.

8.5.4 Mechanical ventilation

a) The mechanical ventilation system is to be of the local exhaust type, in which the intake has a duct extending in the lower part of the space and below the carburetor air intake. Each power exhaust duct pickup is to be permanently and substantially fixed as near as possible below the engine(s) which it serves or at the point(s) where fuel vapours are most likely to accumulate, and above normal accumulations of bilge water.

b) The minimum blower capacity is defined in Tab 1.

c) Blower motors and any other electrical equipment located in the ventilated spaces are to be ignition protected according to ISO/DIS 8846 project (or equivalent test procedure such as UL 1128 - SAE J 11 7 1) or are to be of a certified safe type suitable for use in the considered gases in accordance with IEC 79-0.

   The fans are to be non-sparking type.

d) Blowers are to be mounted as high as practicable above the bilge low point except for blowers designed in combination with bilge pumps which can be run in submerged condition.

e) The blowers may be installed with separate ducting or may be installed in a natural ventilation duct.

f) A notice plate is to be fitted at the steering console stating that the ventilation fan is to be run for at least 5 minutes prior to starting the engine.

Note 1: Necessary ventilation capacity is to be provided in accordance with the engine's air consumption and heat emission as specified by the engine manufacturer.

Table 1 : Minimum blower capacity

Net compartment volume V, in m³	Blower capacity, in m³/min
$V < 1$	1,4
$1 \leq V \leq 3$	1,5 V
$V > 3$	V / 2 + 2,8

Section 10 Tests on Board

1 General

1.1 Application

1.1.1 This Section covers shipboard tests, both at the moorings and during sea trials. Such tests are additional to the workshop tests required in the other sections of this Chapter.

1.2 Purpose of shipboard tests

1.2.1 Shipboard tests are intended to demonstrate that the main and auxiliary machinery and associated systems are functioning properly, in respect of the criteria imposed by the Rules. The tests are to be witnessed by a Surveyor.

1.3 Documentation to be submitted

1.3.1 A comprehensive list of the shipboard tests intended to be carried out by the shipyard is to be submitted to the Society.

For each test, the following information is to be provided:

- scope of the test
- parameters to be recorded.

1.3.2 Alternative procedure

If the proposed list of tests is not in complete accordance with the requirements of this Section, justifications and alternative tests are to be submitted prior to the sea trials.

2 General requirements for shipboard tests

2.1 Trials at the moorings

2.1.1 Trials at the moorings are to demonstrate the following:

a) satisfactory operation of the machinery

b) quick and easy response to operational commands

c) protection of the various installations, as regards:
   - the protection of mechanical parts
   - the safeguards for personnel

d) accessibility for cleaning, inspection and maintenance.

Where the above features are not deemed satisfactory and require repairs or alterations, the Society reserves the right to require the repetition of the trials at the moorings, either wholly or in part, after such repairs or alterations have been carried out.

2.2 Sea trials

2.2.1 Scope of the tests

Sea trials are to be conducted after the trials at the moorings and are to include the following:

a) demonstration of the proper operation of the main and auxiliary machinery, including monitoring, alarm and safety systems, under realistic service conditions

b) check of the propulsion capability when one of the essential auxiliaries becomes inoperative

c) detection of dangerous vibrations by taking the necessary readings when required.

2.2.2 Yachts in a series

If the builder is granted with a BV Mode I survey certificate, and for yachts manufactured in a series, the sea trials of a prototype of the series provided they have been satisfactorily attended by the Surveyor. The MTI plan is to precise basin test on the series yachts.

3 Shipboard tests for machinery

3.1 Conditions of sea trials

3.1.1 Sea trials conditions

Except in cases of practical impossibility, or in other cases to be considered individually, the sea trials are to be carried out:

- with the yacht in the completed condition with permanently installed engine(s) - where applicable - and all usual equipment in place
- under weather and sea conditions corresponding as far as possible to the conditions for which the yacht is intended to operate
- when fitted, with an engine of the largest power for which it has been approved
- in light weight and fully loaded condition.

3.1.2 Power of the machinery

a) The power developed by the propulsion machinery in the course of the sea trials is to be as close as possible to the power for which classification has been requested. In general, this power is not to exceed the maximum continuous power at which the weakest component of the propulsion system can be operated. In cases of diesel engines and gas turbines, it is not to exceed the maximum continuous power for which the engine type concerned has been approved.

b) Where the rotational speed of the shafting is different from the design value, thereby increasing the stresses in excess of the maximum allowable limits, the power developed in the trials is to be suitably modified so as to confine the stresses within the design limits.

3.1.3 Determination of the power and rotational speed

a) The rotational speed of the shafting is to be recorded in the course of the sea trials, preferably by means of a continuous counter.

b) In general, the power is to be determined by means of torsiometric readings, to be effected with procedures and instruments deemed suitable by the Society.

   As an alternative, for reciprocating internal combustion engines, the power may be determined by measuring the fuel consumption and on the basis of the other operating characteristics, in comparison with the results of bench tests of the prototype engine.

   Other methods of determining the power may be considered by the Society on a case by case basis.

3.2 Navigation and manoeuvring tests

3.2.1 Speed trials

a) Where required by the Rules, the speed of the yacht is to be determined using procedures deemed suitable by the Society.

b) The yacht speed is to be determined as the average of the speeds taken in not less than two pairs of runs in opposite directions.

3.2.2 Astern trials

a) The ability of the machinery to reverse the direction of thrust of the propeller in sufficient time, and so to bring the yacht to rest within reasonable distance from maximum ahead service speed, is to be demonstrated and recorded.

b) The stopping times, yacht headings and distances recorded on trials, together with the results of trials to determine the ability of yachts having multiple propellers to navigate and manoeuvre with one or more propellers inoperative, are to be available on board for the use of the Master or designated personnel.

c) Where the yacht is provided with supplementary means for manoeuvring or stopping, the effectiveness of such means is to be demonstrated and recorded as referred to in items a) and b).

For electric propulsion systems, see [3.4].

Alternative procedure for sea trials could be accepted on a case to case basis.

3.3 Tests of diesel engines

3.3.1 General

a) The scope of the trials of diesel engines may be expanded in consideration of the special operating conditions, such as towing, trawling, etc.

b) Where the machinery installation is designed for residual or other special fuels, the ability of engines to burn such fuels is to be demonstrated.

3.3.2 Main propulsion engines driving fixed propellers

Sea trials of main propulsion engines driving fixed propellers are to include the following tests:

a) operation at rated engine speed n_0 for at least 4 hours

b) operation at engine speed corresponding to normal continuous cruise power for at least 2 hours

c) operation at engine speed $n = 1{,}032\ n_0$ for 30 minutes

Note 1: The present test is to be performed only where permitted by the following engine adjustment:

After running on the test bed, the fuel delivery system is to be so adjusted that the engine cannot deliver more than 100% of the rated power at the corresponding speed (overload power cannot be obtained in service).

d) operation at minimum load speed

e) starting and reversing manoeuvres

f) operation in reverse direction of propeller rotation at a minimum engine speed of n = 0,7 n_0 for 10 minutes. These values could be reduced to 0,5 n_0 for 5 min for waterjets and surface propellers.

Note 2: The present test may be performed during the dock or sea trials.

g) tests of the monitoring, alarm and safety systems

h) for engines fitted with independently driven blowers, emergency operation of the engine with the blowers inoperative.

3.3.3 Main propulsion engines driving controllable pitch propellers or reversing gears

a) The scope of the sea trials for main propulsion engines driving controllable pitch propellers or reversing gears is to comply with the relevant provisions of [3.3.2].

b) Engines driving controllable pitch propellers are to be tested at various propeller pitches.

3.3.4 Engines driving generators for propulsion

Sea trials of engines driving generators for propulsion are to include the following tests:

a) operation at 100% power (rated power) for at least 4 hours

b) operation at normal continuous cruise power for at least 2 hours

c) operation at 110% power for 30 minutes

d) operation in reverse direction of propeller rotation at a minimum engine speed 70% of the nominal propeller speed for 10 minutes

Note 1: The present test may be performed during the dock or sea trials.

e) starting manoeuvres

f) tests of the monitoring, alarm and safety systems.

Note 2: The above six tests are to be performed at rated speed with a constant governor setting. The powers refer to the rated electrical powers of the driven generators.

3.3.5 Engines driving auxiliaries

a) Engines driving generators or important auxiliaries are to be subjected to an operational test for at least 4 hours. During the test, the set concerned is required to operate at its rated power for at least 2 hours.

b) It is to be demonstrated that the engine is capable of supplying 100% of its rated power and, in the case of shipboard generating sets, account is to be taken of the times needed to actuate the generator’s overload protection system.

3.4 Tests of electric propulsion system

3.4.1 Dock trials

a) The dock trials are to include the test of the electrical production system, the power management and the load limitation.

b) A test of the propulsion plant at a reduced power, in accordance with dock trial facilities, is to be carried out. During this test, the following are to be checked:

- electric motor rotation speed variation
- functional test, as far as practicable (power limitation is to be tested with a reduced value)
- protection devices
- monitoring and alarm transmission including interlocking system.

c) Prior to the sea trials, an insulation test of the electric propulsion plant is to be carried out.

3.4.2 Sea trials

Testing of the performance of the electric propulsion system is to be effected in accordance with an approved test program.

This test program is to include at least:

- Speed rate of rise
- Endurance test:
  - operation at normal continuous cruise power for at least 4 hours
  - 1 hour at 100% rated output power with winding temperature rise below 2°K per hour, according to IEC publication 60034-1
  - operation in reverse direction of propeller rotation at the maximum torque or thrust allowed by the propulsion system for 10 minutes

- Check of the crash astern operation in accordance with the sequence provided to reverse the speed from full ahead to full astern, in case of emergency. During this test, all necessary data concerning any effects of the reversing of power on the generators are to be recorded, including the power and speed variation
- Test of functionality of electric propulsion, when manoeuvring and during the yacht turning test
- Test of power management performance: reduction of power due to loss of one or several generators to check, in each case, the power limitation and propulsion availability.

3.5 Tests of gears

3.5.1 Tests during sea trials

During the sea trials, the performance of reverse and/or reduction gearing is to be verified, both when running ahead and astern.

In addition, when the power per shaft line exceeds 220 kW, the following checks are to be carried out:

- check of the bearing and oil temperature
- detection of possible gear hammering, where required by NR467 Rules for Steel Ships, Pt C, Ch 1, Sec 9, [3.5.1]
- test of the monitoring, alarm and safety systems.

3.5.2 Check of the tooth contact

When the power per shaft line exceeds 220 kW, the following checks are to be carried out:

a) Prior to the sea trials, the tooth surfaces of the pinions and wheels are to be coated with a thin layer of suitable coloured compound.

   Upon completion of the trials, the tooth contact is to be inspected. The contact marking is to appear uniformly distributed without hard bearing at the ends of the teeth and without preferential contact lines.

   The tooth contact is to comply with Tab 1.

b) The verification of tooth contact at sea trials by methods other than that described above will be given special consideration by the Society.

c) The tooth contact is to be checked when the casing is cast steel.

   In the case of reverse and/or reduction gearing with several gear trains mounted on roller bearings, manufactured with a high standard of accuracy and having an input torque not exceeding 20000 N·m, the check of the tooth contact may be reduced at the Society's discretion.

   Such a reduction may also be granted for gearing which has undergone long workshop testing at full load and for which the tooth contact has been checked positively.

   In any case, the teeth of the gears are to be examined by the Surveyor after the sea trials. Subject to the results, additional inspections or re-examinations after a specified period of service may be required.

Table 1 : Tooth contact for gears

Heat treatment and machining	Percentage of tooth contact	
	across the whole face width	of the tooth working depth
quenched and tempered, cut	70	40
• quenched and tempered, shaved or ground • surface-hardened	90	40

3.6 Tests of main propulsion shafting and propellers

3.6.1 Shafting alignment

Where alignment calculations are required to be submitted in pursuance of Ch 1, Sec 2, [7], the alignment conditions are to be checked on board by the Shipyard, as follows:

a) Shafting installation and intermediate bearing position, before and during assembling of the shafts:
   - optical check of the relative position of bushes after fitting
   - check of the flanged coupling parameters (gap and sag)
   - check of the centring of the shaft sealing glands.

b) Engine (or gearbox) installation, with floating yacht:
   - check of the engine (or gearbox) flanged coupling parameters (gap and sag)
   - check of the crankshaft deflections before and after the connection of the engine with the shaft line, by measuring the variation in the distance between adjacent webs in the course of one complete revolution of the engine.

Note 1: The yacht is to be in the loading conditions defined in the alignment calculations.

c) Load on the bearings:
   - check of the intermediate bearing load by means of jack-up load measurements
   - check of the bearing contact area by means of coating with an appropriate compound.

3.6.2 Shafting vibrations

Torsional vibration measurements are to be carried out where required by Ch 1, Sec 2, [6.1.1]. The type of the measuring equipment and the location of the measurement points are to be specified.

3.6.3 Bearings

The temperature of the bearings is to be checked under the machinery power conditions specified in [3.1.2].

3.6.4 Stern tube sealing gland

The stern tube oil system is to be checked for possible oil leakage through the stern tube sealing gland.

3.6.5 Propellers

a) For controllable pitch propellers, the functioning of the system controlling the pitch from full ahead to full astern position is to be demonstrated. It is also to be checked that this system does not induce any overload of the engine.

b) The proper functioning of the devices for emergency operations is to be tested during the sea trials.

3.7 Tests of piping systems

3.7.1 Hydrostatic tests of piping after assembly on board

a) When the hydrostatic tests of piping referred to in Ch 1, Sec 4, [6.4.2] are carried out on board, they may be carried out in conjunction with the leak tests required in [3.7.3].

b) Low pressure pipes, such as bilge or ballast pipes are to be tested, after fitting on board, under a pressure at least equal to the maximum pressure to which they can be subjected in service.

c) Fuel pipes are to be subjected, after fitting on board, to a hydraulic test under a pressure not less than 1,5 times the design pressure, with a minimum of 4 bars.

3.7.2 Leak tests

Except otherwise permitted by the Society, all piping systems are to be leak tested under operational conditions after completion on board at a pressure not less than:

- 1,25 times the design pressure p, if welded joints have been made on board, or
- the setting pressure of safety valves or other overpressure protective devices in the alternative case.

3.7.3 Functional tests

During the sea trials, piping systems serving propulsion and auxiliary machinery, including the associated monitoring and control devices, are to be subjected to functional tests at the nominal power of the machinery. Operating parameters (pressure, temperature, consumption) are to comply with the values recommended by the equipment manufacturer.

3.7.4 Performance tests

The Society reserves the right to require performance tests, such as flow rate measurements, should doubts arise from the functional tests.

3.8 Tests of steering gear

3.8.1 General

a) The steering gear is to be tested during the sea trials under the conditions stated in [3.1] in order to demonstrate, to the Surveyor's satisfaction, that the applicable requirements of Ch 1, Sec 3 are fulfilled.

b) For controllable pitch propellers, the propeller pitch is to be set at the maximum design pitch approved for the maximum continuous ahead rotational speed.

c) If the yacht cannot be tested at the deepest draught, alternative trial conditions will be given special consideration by the Society. In such case, the yacht speed corresponding to the maximum continuous number of revolutions of the propulsion machinery may apply.

3.8.2 Tests to be performed

Tests of the steering gear are to include at least:

a) functional test of the main and auxiliary steering gear with demonstration of the performances required by Ch 1, Sec 3

b) test of the steering gear power units, including transfer between steering gear power units

c) test of the isolation of one power actuating system, checking the time for regaining steering capability

d) test of the hydraulic fluid refilling system

e) test of the alternative power supply required by Ch 1, Sec 3

f) test of the steering gear controls, including transfer of controls and local control

g) test of the means of communication between the navigation bridge, the engine room and the steering gear compartment

h) test of the alarms and indicators

i) where the steering gear design is required to take into account the risk of hydraulic locking, a test is to be performed to demonstrate the efficiency of the devices intended to detect this.

Note 1: Tests d) to i) may be carried out either during the mooring trials or during the sea trials.

Note 2: For yachts of length less than 24 m, the Society may accept departures from the above list, in particular to take into account the actual design features of their steering gear.

Note 3: Azimuth thrusters are to be subjected to the above tests, as far as applicable.

4 Inspection of machinery after sea trials

4.1 General

4.1.1

a) For all types of propulsion machinery, those parts which have not operated satisfactorily in the course of the sea trials, or which have caused doubts to be expressed as to their proper operation, are to be disassembled or opened for inspection.

   Machinery or parts which are opened up or disassembled for other reasons are to be similarly inspected.

b) Should the inspection reveal defects or damage of some importance, the Society may require other similar machinery or parts to be opened up for inspection.

c) An exhaustive inspection report is to be submitted to the Society for information.

4.2 Diesel engines

4.2.1

a) For all diesel engines, where it is technically possible, the following items are to be verified:
   - the deflection of the crankshafts
   - the cleanliness of the lubricating oil filters.

b) In the case of propulsion engines for which power tests have not been carried out in the workshop, some parts, agreed upon by the interested parties, are to be disassembled for inspection after the sea trials.

Part C
Machinery, Electricity, Automation and Fire Protection

CHAPTER 2
ELECTRICAL INSTALLATIONS

Section 1 General Requirements

1 General

1.1 Application

1.1.1 The requirements of this Chapter apply to electrical installations on yachts assigned with service notation **yacht** and **charter yacht** completed with the additional service feature **motor** or **sailing**.

Where the word "yachts" is used in the subsequent sections, it means yachts and charter yachts.

1.1.2 Charter yachts carrying more than 36 passengers are not covered by this Chapter and are to comply with applicable rules for ships granted with service notation **passenger ship**. Requirements specified in NR467 Rules for Steel ships Part C, Chapter 1 and NR467, Part D, Ch11, Sec 5 apply.

1.1.3 In the present Chapter, the length reference to 24 m applies to L_{LL} as defined in Pt A, Ch 1, Sec 1, [3.2.2].

1.2 National regulations

1.2.1 When the Administration of the State whose flag the yacht is entitled to fly has issued specific rules covering electricity, the Society may accept such rules for classification purposes in lieu of those given in this Chapter.

In this case, it is the responsibility of the Interested Party to specify to the Society the condition of operation of the Yacht and the applicable specific Flag Rules.

In such cases, a special notation regarding the above is entered on the Certificate of Classification of the yacht.

1.3 References to other regulations and standards

1.3.1 The Society may refer to other regulations and standards when deemed necessary. These include the IEC publications, notably the IEC 60092 series.

1.3.2 When referred to by the Society, publications by the International Electrotechnical Commission (IEC) or other internationally recognised standards, are those currently in force at the date of agreement for ship classification.

2 Documentation to be submitted

2.1

2.1.1 The documents listed in Tab 1 are to be submitted.

Table 1 : Documents to be submitted

No.	I/A **(1)**	Document
1	A	Single line diagram of electrical installation
2	A	General arrangement diagram of the yacht showing the location of electrical equipment (batteries, generators, switchboards, battery chargers, shore connection sockets, etc.) and their associated IP
3	I	Electrical power balances (AC and DC installations)
4	A	List of circuits including, for each supply and distribution circuit, data concerning the nominal current, the cable type and cross-section, nominal and setting values of the protective and control devices
5	A	Calculation of short-circuits currents for each installation in which the sum of rated power of the energy sources which may be connected contemporaneously to the network is greater than 500 kVA (kW)
6	A	List of main electrical equipments including type and manufacturer name
7	A	Single line diagram and detailed diagram of the main switchboard
8	A **(2)**	Single line diagram and detailed diagram of the emergency switchboard
9	A **(2)**	Diagram of the supply, monitoring and control systems of the steering gear system
10	A **(2)**	Detailed diagram of the navigation-light switchboard
11	A **(2)**	Diagram of the remote stop system (ventilation, fuel pump, fuel valves, etc.)
12	A **(3)**	Diagram of the general emergency alarm system and other intercommunication systems

(1) A: to be submitted for approval
I: to be submitted for information.
(2) for yachts equal or over 24 m in length
(3) for yachts of 500 gross tonnage and above

The list of documents requested is to be intended as guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

Plans are to include all the data necessary for their interpretation, verification and approval.

Unless otherwise agreed with the Society, documents for approval are to be sent in triplicate if submitted by the Shipyard and in four copies if submitted by the equipment supplier.

Documents requested for information are to be sent in duplicate.

In any case, the Society reserves the right to require additional copies when deemed necessary.

3 Definitions

3.1 General

3.1.1 Unless otherwise stated, the terms used in this Chapter have the definitions laid down by the IEC standards.

The definitions given in the following requirements also apply.

3.2 Essential services

3.2.1 Services essential for the navigation, steering or manoeuvring of the yacht, or the safety of human life.

3.2.2 For yachts whose length is less than 24 m, essential services may include but are not limited to following services:

- starting equipment of main propulsion engines
- steering gear
- bilge pumps
- bilge level detection
- necessary lighting
- navigation lights
- navigational equipment
- equipment necessary for the control of the sails (for sailing yachts).

3.2.3 For yachts whose length is equal or greater than 24 m, essential services may in addition to those listed in [3.2.2] include but are not limited to following additional services:

- fuel supply pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines
- electric generators and associated power sources supplying the above equipments
- windlasses
- fire detection and alarm system
- fire extinguishing systems
- ventilation fans for engine rooms
- starting air compressor
- emergency battery charger
- internal safety communication equipment
- services necessary for maintaining conditions of habitability for people onboard (heating, sanitary and fresh water, domestic refrigeration and cooking).

3.3 Low-voltage systems

3.3.1 Alternating current systems with rated voltages greater than 50 V r.m.s. up to 1000 V r.m.s. inclusive and direct current systems with a maximum instantaneous value of the voltage under rated operating conditions greater than 50 V up to 1500 V inclusive.

3.4 Safety voltage

3.4.1 Voltage which does not exceed 50 V a.c. r.m.s between conductors, or between any conductor and earth, in a circuit isolated from the supply by means such as a safety isolating transformer, or convertor with separate windings.

Voltage which does not exceed 50 V d.c. between conductors, or between any conductor and earth, in a circuit which is isolated from higher voltage circuits.

Note 1: Consideration should be given to the reduction of the limit of 50 V under certain conditions, such as wet surroundings or exposure to heavy seas or where direct contact with live parts is involved.

Note 2: The voltage limit should not be exceeded either at full load or at no-load, but it is assumed, for the purpose of this definition, that any transformer or convertor is operated at its rated supply voltage.

3.5 DC systems of distribution

3.5.1 Two-wire d.c. system

A d.c. system comprising two conductors only, between which the load is connected.

3.6 AC systems of distribution

3.6.1 Single-phase two-wire a.c. system

A single-phase a.c. system comprising two conductors only, between which the load is connected.

3.6.2 Single-phase three-wire a.c. system

A single-phase a.c. system comprising two conductors and a neutral wire, the supply being taken from the two outer conductors or from the neutral wire and either outer conductor, the neutral wire carrying only the difference current.

3.6.3 Three-phase three-wire system

A system comprising three conductors connected to a three-phase supply.

3.6.4 Three-phase four-wire system

A system comprising four conductors of which three are connected to a three-phase supply and the fourth to a neutral point in the source of supply.

3.7 Hull return system

3.7.1 A system in which insulated conductors are provided for connection to one pole or phase of the supply, the hull of the yacht or other permanently earthed structure being used for effecting connections to the other pole or phase.

3.8 Earthed

3.8.1 Connected to the general mass of the hull of the yacht in such a manner as will ensure at all times an immediate discharge of electrical energy without danger.

Note 1: A conductor is said to be "solidly earthed" when it is electrically connected to the hull without a fuselink, switch, circuit breaker, resistor, or impedance, in the earth connection.

Note 2: In the USA, "grounded" is used instead of "earthed".

3.9 Main source of electrical power

3.9.1 A source intended to supply electrical power to the main switchboard for distribution to all services necessary for maintaining the yacht in normal operational and habitable condition.

3.10 Main switchboard

3.10.1 A switchboard which is directly supplied by the main source of electrical power and is intended to distribute electrical energy to the yacht's services.

3.11 Emergency source of electrical power

3.11.1 A source of electrical power, intended to supply the emergency switchboard in the event of failure of the supply from the main source of electrical power.

3.12 Emergency condition

3.12.1 A condition under which any services needed for normal operational and habitable conditions are not in working order due to failure of the main source of electrical power.

3.13 Emergency switchboard

3.13.1 A switchboard which in the event of failure of the main electrical power supply system is directly supplied by the emergency source of electrical power and is intended to distribute electrical energy to the emergency services.

3.14 Distribution board

3.14.1 A switchgear and controlgear assembly arranged for the distribution of electrical energy to final circuits.

3.15 Engine negative terminal

3.15.1 Terminal on the engine to which the negative cable of a battery system is connected.

3.16 Final circuit

3.16.1 Portion of a wiring system extending beyond the final overcurrent protection device for that circuit.

3.17 Overcurrent protection device

3.17.1 Device, such a fuse or circuit breaker, designed to interrupt the circuit when the current exceeds a predetermined value for a predetermined time.

3.18 Circuit breaker

3.18.1 Mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions, and also making, carrying for a specified time and breaking currents under specified abnormal conditions such as those of a short-circuit.

3.19 Residual (differential) Current Device (RCD) / Ground Fault Circuit Interrupter (GFCI)

3.19.1 Mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions.

Note 1: RCD are recognized as reducing the risk of injury to people from electric shock.

3.20 Fuse

3.20.1 Device that by fusing of one or more of its specifically designed and proportioned components, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device.

3.21 Protective conductor

3.21.1 Conductor provided for purposes of safety, for example, protection against electric shock by electrically connecting any of the exposed and extraneous conductive parts of electrical equipment of a yacht with non-metallic hull to the yacht's main earth.

Note 1: In the case of a yacht with metallic hull, exposed and extraneous conductive parts may be bonded to the yacht's hull by permanent and reliable metal to metal joints of negligible impedance.

3.22 Bond

3.22.1 Connection of non-current carrying parts to ensure continuity of electrical connection, or to equalize the potential between parts comprising, for example, the armour or lead sheath of adjacent length of cable, the bulkhead, etc. For example bulkhead and cables in a radio-receiving room.

3.23 Neutral conductor

3.23.1 Conductor electrically connected to the neutral point and capable of contributing to the transmission of electrical energy.

3.24 Sheath

3.24.1 Uniform and continuous tubular covering of metallic or non-metallic material, generally extruded around one or more insulated conductors.

3.25 Batteries

3.25.1 Vented battery

A vented battery is one in which the cells allow products of electrolysis and evaporation to escape freely to the atmosphere and can receive additions to the electrolyte.

3.25.2 Valve regulated sealed battery

A valve regulated sealed battery is one in which the cells are closed but have a valve which allows the escape of gas if the internal pressure exceeds a predetermined value. The electrolyte cannot normally be replaced.

3.26 Cable trunking

3.26.1 System of enclosures comprising a base with a removable cover intended for the complete surrounding of insulated conductors, cables or cords and for the accommodation of other electrical equipment.

3.27 Captive-spade terminal

3.27.1 Conductor terminal component which is maintained in connection to the screw or stud even when the threaded terminal fastener is loose.

3.28 Generator

3.28.1 A device which creates d.c. or a.c. (alternator) power for distribution to the electrical system onboard a yacht.

3.29 Accessible

3.29.1 Capable of being reached for inspection, removal or maintenance without removal of the permanent structure of the yacht.

3.30 Readily accessible

3.30.1 Capable of being reached quickly and safely for effective use without the use of tools.

3.31 Certified safe-type equipment

3.31.1 Certified safe-type equipment is electrical equipment of a type for which a national or other appropriate authority has carried out the type verifications and tests necessary to certify the safety of the equipment with regard to explosion hazard when used in an explosive gas atmosphere.

Certified safe-type equipment is to be designed and constructed to comply with IEC 60079 series.

4 Environmental conditions

4.1 General

4.1.1 The electrical components of installations are to be designed and constructed to operate satisfactorily under the environmental conditions on board.

In particular, the conditions shown in the tables in this Article are to be taken into account.

4.2 Ambient air and cooling water temperatures

4.2.1 Electrical equipment is to be designed to operate satisfactorily under the various temperature parameters indicated in Tab 2 and Tab 3.

Table 2 : Ambient air temperature

Location	Temperature range °C	
Enclosed spaces	+ 5	+ 45
Exposed decks	– 25	+ 45
Inside console or fitted on combustion engine or similar	+ 5	+ 55

Table 3 : Water temperature

Coolant	Temperature range °C	
Sea water	0	+ 32

4.3 Humidity

4.3.1 For yachts classed for unrestricted service, the humidity ranges in Tab 4 are applicable in relation to the various locations of installation.

Table 4 : Humidity

Location	Humidity
General	95% at 45°C
Air conditioned areas	Different values may be considered on a case by case basis

4.4 Salt mist

4.4.1 The applicable salt mist content in the air is to be 1 mg/m³.

4.5 Inclination

4.5.1 Electrical equipment is to be designed to continue to operate satisfactorily with the yacht at the inclinations angles from normal specified in Ch 1, Sec 1, Tab 1.

4.5.2 For sailing yachts a maximum heel angle of 45° on either tack is to be considered.

4.6 Vibrations

4.6.1 In relation to the location of the electrical components, the vibration levels given in Tab 5 are to be assumed. The necessary damping elements on machinery supports will be fitted to reach this level.

4.6.2 The natural frequencies of the equipment, their suspensions and their supports are to be outside the frequency ranges specified.

Where this is not possible using a suitable constructional technique, the equipment vibrations are to be dumped so as to avoid unacceptable amplifications.

Table 5 : Vibration levels

Location	Frequency range, in Hz	Displacement amplitude, in mm	Acceleration amplitude, in g
Machinery spaces, command and control stations, accommodation spaces, exposed decks	from 2,0 to 13,2 from 13,2 to 100	1,0 –	– 0,7
On air compressors, on diesel engines and similar	from 2,0 to 25,0 from 25,0 to 100	1,6 –	– 4,0
Masts	from 2,0 to 13,2 from 13,2 to 50	3,0 –	– 2,1

5 Quality of power supply

5.1 General

5.1.1 Electrical components are to be so designed and manufactured that they are capable of operating satisfactorily under the variations of voltage, frequency and harmonic distortion of the power supply specified from [5.2] to [5.4].

5.2 A.c. distribution systems

5.2.1 For alternating current components the voltage and frequency variations of power supply shown in Tab 6 are to be assumed.

5.3 D.c. distribution systems

5.3.1 The nominal d.c. voltage tolerance at the battery terminals over which all d.c. equipment is to operate is ± 10%.

The yacht's essential services are to remain functional to the minimum voltage at the battery terminals.

Note 1: When battery chargers/battery combination are used as d.c. power systems, adequate measures are to be taken to keep the voltage within the specified limits during charging, quick charging and discharging of the battery.

Table 6 : Voltage and frequency variations of power supply in a.c.

Parameter	Variations	
	Continuous	Transient
Voltage	+ 6% – 10%	± 20% (recovery time: 1,5 s)
Frequency	± 5%	± 10% (recovery time: 5 s)
Note 1: For alternating current components supplied by emergency generating sets, different variations may be considered.		

5.4 Harmonic distortions

5.4.1 For components intended for systems without substantially static converter loads and supplied by synchronous generators, it is assumed that the total voltage harmonic distortion does not exceed 5%, and the single harmonic does not exceed 3% of the nominal voltage.

6 Electromagnetic susceptibility

6.1

6.1.1 Electrical apparatus, batteries, generators, electrical cables are not to be located, as far as practicable near magnetic compass, or other navigational aids and instruments likely to be sensitive to electromagnetic disturbances.

Note 1: For yachts greater than 24 m, IEC60533 and IEC60945 may be used for guidance.

Section 2 System Design

1 Supply systems and characteristics of the supply

1.1 Supply systems

1.1.1 The following distribution systems may be used:

a) On d.c. installations:
- two-wire insulated
- two-wire with negative earthed

b) On a.c. installations:
- single-phase two-wire insulated
- single-phase two-wire with neutral earthed
- three-phase three-wire with neutral insulated or directly earthed
- three-phase four-wire with neutral earthed, but without hull return (TN-C Type)
- three-phase five-wire with neutral earthed, but without hull return (TN-S Type).

1.1.2 The hull return system of distribution is not to be used for voltage greater than 50 Volts.

1.1.3 The requirement of [1.1.2] does not preclude, under conditions approved by the Society, the use of:

a) limited and locally earthed system, or

b) insulation level monitoring devices provided the circulation current does not exceed 30 mA under the most unfavourable conditions.

Note 1: Limited and locally earthed systems such as starting and ignition systems of internal combustion engines.

1.2 Recommended voltage

1.2.1 Recommended voltage for d.c. voltage systems are 12 V, 24 V and 48 V. Other voltages are to be considered by the Society on case by case basis.

1.2.2 The recommended values of nominal voltage, frequencies and maximum voltage permitted for a.c. yacht's service system of supply are given in Tab 1.

Table 1 : AC voltages and frequencies for yacht's service system of supply

No.	Application	Recommended nominal voltages V	Recommended nominal frequencies Hz	Maximum voltage V
1	Power, cooking and heating:			
	a) equipment securely fixed and permanently connected	Single phase 120/230 Three-phase 400/440	Single/three phase 50/60	Single phase 250 Three-phase 1000
	b) socket-outlet supplying equipment which is earthed	Single phase 120/230	Single phase 50/60	Single phase 500
2	Fixed lighting and outlets intended for purposes not mentioned in items 1 and 3 but intended for apparatus with reinforced or double insulation or connected by a flexible cord or cable incorporating a protective conductor	Single phase 120/230	Single phase 50/60	Single phase 250
3	Socket outlets for use where extra precautions against shock are necessary:			
	a) supplied with or without the use of isolating transformers	Single phase 24	Single phase 50/60	Single phase 55
	b) where a safety isolating transformer is used supplying one consuming device only. Both conductors of such systems should be insulated from earth	Single phase 120/230	Single phase 50/60	Single phase 250
Note 1: The use of the nominal voltages as given in IEC 60092-201 is permitted.				

2 Sources of electrical power

2.1 Yachts less than 24 metres in length

2.1.1 For yachts whose length is less than 24 m, requirements mentioned in [2.2] and [2.3] may be omitted.

2.1.2 Those yachts are to be fitted with a source of electrical power of sufficient capacity to supply all essential services necessary for their normal operation. The source of power may consist of batteries and d.c. or a.c. generator(s).

2.1.3 Where d.c. generator(s) are provided, they are to be capable of supplying the total load and simultaneously be capable of charging the batteries to 80% charge within 10 hours.

2.1.4 If required, a.c. power may be provided by one or a combination of the following means:

a) one or more shore-power connections

b) inverter supplying a.c. power from the yachts d.c. system

c) on-board a.c. generator(s) supplying the required system load.

2.1.5 Generator may be driven by its own prime mover, or be powered from propulsion machinery, or be a shaft generator.

2.1.6 Where the main source of electrical power consists of a single a.c. generator, an alternative means of starting the generator is to be provided.

2.2 Main source of electrical power

2.2.1 A main source of electrical power is to be provided, of sufficient capacity to supply all electrical essential services necessary for maintaining the yacht in normal operational and habitable conditions without recourse to the emergency source of electrical power.

2.2.2 Where electrical energy is required for services necessary to the propulsion, navigation and safety of the yacht, the main source of electrical power is to consist of at least two generating sets. The capacity of these generating sets is to be such that in the event of any one generating set being stopped it will still be possible to supply all services necessary to provide normal operational conditions of propulsion and safety.

Such capacity is, in addition, to be sufficient to start the largest motor without causing any other motor to stop or having any adverse effect on other equipment in operation.

2.2.3 Generators driven by the propulsion machinery may be accepted as forming part of the main source of electrical power, if in all sailing and manoeuvring conditions including the propeller being stopped, the capacity of these generators is sufficient to provide the electrical power to comply with [2.2.1]. They are to be not less effective and reliable than the independent generating sets. One propulsion engine being unavailable is not to result in more than one generator being unavailable as well.

2.2.4 For yachts less than 500 gross tonnage, no more than one of the generators can be driven by the propulsion machinery.

2.2.5 For yachts of 500 gross tonnage and over and charter yachts intended to carry more than 12 passengers, the following arrangements are to be provided to maintain or restore the electrical supply to equipment necessary for propulsion and steering and to ensure safety of the yacht in the case of loss of any one of the generators in service.

a) Where the electrical power is normally supplied by more than one generator set simultaneously in parallel operation, provision of protection, including automatic disconnection of sufficient non-essential services should be made to ensure that the remaining generating sets are kept in operation.

b) Where the electrical power is normally supplied by one generator, provision shall be made, upon loss of power, for automatic starting and connecting to the main switchboard of stand-by generator(s) of sufficient capacity with automatic restarting of the essential services, in sequential operation if required. Starting and connection to the main switchboard of the stand-by generator is to be preferably within 30 seconds, but in any case not more than 45 seconds after loss of power.

2.2.6 For the purpose of calculating the necessary capacity, it is essential to consider which consumers can be expected to be in use simultaneously, in the various operational conditions of the yacht.

2.2.7 Electrical starting arrangements of generating sets are to have two separate storage batteries or may be supplied by two separate circuits from main engine storage batteries, when these are provided. In the case of a single auxiliary engine, one battery is acceptable. The combined capacity of the batteries is to be sufficient for at least three starts for each engine.

Provision is to be made to maintain the stored energy at all times.

2.2.8 Where transformers, converters or similar appliances constitute an essential part of the electrical supply system to ensure the propulsion and steering of the yacht, the system is to be so arranged as to ensure the same continuity of supply as stated in this sub-article.

This may be achieved by arranging at least two three-phase or three single-phase transformers supplied, protected and installed so that with any one transformer not in operation, the remaining transformer(s) is (are) sufficient to ensure the supply to the services stated in [2.2.1].

Each transformer required is to be located as a separate unit with separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides.

Where single phase transformers are used, only one spare element is required for each different type of transformer if special precautions are taken to rapidly replace the faulty one.

2.3 Emergency source of electrical power

2.3.1 A self-contained emergency source of electrical power is to be provided.

For multihull yachts, where the main source of electrical power is located in two different hulls, each of which having its own self-contained power system, including power distribution and control systems, completely independent of each other and so arrange that a fire or other casualty in any one hull will not affect the power distribution from the other, or to the services required in [2.3.6] to [2.3.9], the requirements of this Section may be considered as satisfied without an additional emergency source of electrical power, provided there is at least in each hull one generating set of sufficient capacity to satisfy the requirement of [2.3.6] to [2.3.9].

2.3.2 For yachts less than 500 gross tonnage, the emergency source of power, associated transforming equipment, emergency switchboard and emergency lighting switchboard are to be located outside the machinery spaces and as far as practicable above the uppermost continuous deck.

2.3.3 For yachts of 500 gross tonnage and over and charter yachts intended to carry more than 12 passengers, the emergency source of power, associated transforming equipment, if any, transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the uppermost continuous deck and are to be readily accessible from the open deck. They are not to be located forward of the collision bulkhead.

For yachts less than 3000 gross tonnage, the emergency generator may be located below the uppermost continuous deck provided that it is protected from the consequences of a fire or flooding by watertight and fire-resisting decks and bulkheads in accordance with Part C, Chapter 4. In all case the emergency generator is to be easily accessible from the open deck, and it is to be separated from the main generators and the main switchboard as required in [2.3.4]. The emergency generator compartment is not to have any partition in common with the machinery space and is to be situated more than one metre away from the side shell plating.

2.3.4 The space containing the emergency source of electrical power, associated transforming equipment, if any, the transitional source of emergency electrical power and the emergency switchboard are not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard.

Where this is not practicable, the contiguous boundaries are to be fire insulated as required for boundaries of machinery spaces of category A in Ch 4, Sec 4, [2.2.1] or Ch 4, Sec 7, [2.1.4], as applicable.

2.3.5 The location of the emergency source of electrical power and associated transforming equipment, if any, the transitional source of emergency power, the emergency switchboard and the emergency electric lighting switchboards in relation to the main source of electrical power, associated transforming equipment, if any, and the main switchboard is to be such as to ensure to the satisfaction of the Society that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, and the main switchboard or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power.

2.3.6 The emergency source of electrical power is to be capable of supplying simultaneously at least the following services for a period of 3 hours:

a) the emergency lighting at every muster and embarkation station and over the sides
b) the emergency lighting in all service and accommodation alleyways, stairways and exits
c) the emergency lighting in the machinery spaces and at the navigation bridge
d) the emergency lighting at the main and emergency switchboards and at the storage and operation areas of the emergency fire pump required in Ch 4, Sec 5, Tab 1
e) the emergency lighting in the room which is located the engine room fixed-fire extinguishing system if any
f) the navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force and/ or by the Flag Authority
g) the ship’s whistle if electrically powered
h) the fire detection and fire alarm system
i) the radiocommunication equipment required by the Flag Authority
j) the control and alarm system of the fixed fire-fighting system

Note 1: Attention is drawn to compliance with possible national regulations.

2.3.7 The emergency fire pump required in Ch 4, Sec 5, Tab 1, if electrically driven, is to be fed by a source of power other than that supplying the main fire pump for a period of 3 hours.

2.3.8 For yachts of 500 gross tonnage and over the emergency source of electrical power is to be capable of supplying simultaneously for a period of 18 hours the following services in addition to those required in [2.3.6]:

a) general alarm system required in [3.10]
b) the public address system or other effective means of communication where required in [3.10.2]
c) the means of communication between the navigation bridge and the steering gear compartment required in [3.11.1]
d) the means of communication between the navigating bridge and the position in the machinery space or control room from which the engines may be controlled required in [3.11.1]
e) intermittent operation of the daylight signalling lamp, the ship's whistle, the manually operated call points and all internal signals that are required in an emergency
f) one of the fire pumps required in Ch 4, Sec 8, [2.3.2] if dependent upon an electrical source of power for its operation
g) shipborne navigational equipment required by the Flag Authority.

2.3.9 For charter yachts intended to carry more than 12 passengers the emergency source of electrical power is to be capable of supplying simultaneously for a period of 36 hours the following services in addition to those required in [2.3.6] and [2.3.8]:

a) the automatic sprinkler pump required in Ch 4, Sec 13, [5]
b) the emergency bilge pump and all the equipment essential for the operation of electrically powered remote control bilge valves required in Ch 1, Sec 5
c) the low-location lighting required in Ch 4, Sec 1, [2.1.4], where electric type.

2.3.10 For charter yachts intended to carry more than 12 passengers and having the navigation notation **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, [2.4], the Society may, if satisfied that an adequate standard of safety would be attained, accept a lesser period of time that the periods specified in [2.3.9] but not less than 12 hours.

2.3.11 The emergency source of power may be:

a) a generator set driven by an auxiliary engine with a fuel oil supply and a cooling system independent from the main engine, or
b) a storage battery.

2.3.12 Where the emergency source of electrical power is an accumulator battery, it is to be capable of:

a) carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage
b) automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power, and
c) immediately supplying at least those services specified in [2.3.6] to [2.3.9].

2.3.13 An indicator is to be mounted in a continuously manned control position, to indicate when the battery constituting either the emergency source of electrical power or the transitional source of emergency electrical power referred to in [2.3.12] and [2.3.15] is being discharged.

2.3.14 Where the emergency source of electrical power is a generator, it is to be:

a) driven by a suitable prime mover with an independent supply of fuel, having a flash point (closed cup test) of not less than 43°C
b) started automatically upon failure of the main source of electrical power supply to the emergency switchboard and is to be automatically connected to the emergency switchboard; those services referred to in [2.3.6] to [2.3.9] are then transferred automatically to the emergency generator
c) provided with an automatic starting system and prime mover capable to carry its full rated load as quickly as is safe and practicable with a maximum of 45 s
d) provided with a dedicated fuel oil supply tank fitted with a low level alarm, arranged at level ensuring sufficient fuel oil capacity for the emergency services for the period of time as required in [2.3.6] to [2.3.9]
e) provided with a transitional source of emergency electrical power according to [2.3.15] when fitted onboard charter yachts intended to carry more than 12 passengers.

2.3.15 The transitional source of emergency electrical power required by [2.3.14] item e) is to consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period with 12% above or below its nominal voltage and so arranged as to supply automatically in the event of failure of the main and emergency source of electrical power at least the following services for half an hour:

a) the lighting required by [2.3.6], items a) to d)
b) the services required by [2.3.6] item e) and [2.3.8] items a) to e), unless such devices have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

2.3.16 For starting arrangements of emergency generating sets, following requirements apply:

a) Emergency generating sets are to be capable of being readily started in their cold condition at a temperature of 0°C. If this is impracticable, or if lower temperatures are likely to be encountered, provision acceptable to the Society is to be made for the maintenance of heating arrangements, to ensure ready starting of the generating sets.

b) Each emergency generating set arranged to be automatically started is to be equipped with starting devices approved by the Society with a stored energy capability of at least three consecutive starts.

   The source of stored energy is to be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. In addition, a second source of energy is to be provided for an additional three starts within 30 minutes, unless manual starting can be demonstrated to be effective.

c) Electrical starting systems is to be maintained from the emergency switchboard.

d) All of these starting, charging and energy storing devices are to be located in the emergency generator space; these devices are not to be used for any purpose other than the operation of the emergency generating set.

2.3.17 The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be adequately protected at the main switchboard against overload and short-circuit and which is to be automatically disconnected at the emergency switchboard upon failure of the main source of electrical power.

2.3.18 Provision is to be made for the periodic testing of the complete emergency system and is to include the testing of automatic starting arrangements, where provided.

3 Distribution

3.1 Earthed neutral systems

3.1.1 In earthed neutral systems, the source of power is connected direct to earth, and all exposed conductive parts of the installation are connected to the earthed point of the yacht’s power system by protective conductor(s).

3.1.2 The neutral conductor is to be earthed only at the source of power, for example, at the onboard generator or secondary of transformer.

3.1.3 The yacht’s a.c. neutral is to be arranged to be earthed only at the shore-power source when the yacht’s a.c. system is supplied from shore (i.e. the yacht’s a.c. neutral is to be disconnected from the yacht’s earth when the shore power is connected), unless the yacht is fitted with an isolating transformer.

3.1.4 System earthing is to be effected by means independent of any earthing arrangements of the non-current-carrying parts.

3.1.5 Earthed neutral systems are to be so designed that the potential earth fault current:

a) does not exceed the design capacity of any part of the system

b) is of sufficient magnitude to operate any protection.

Note 1: Where the neutral point is connected directly to earth, the earth loop impedance is to be low enough to permit the passage of current at least three times the fuse rating for fuse protected circuits or 1.5 times the tripping current of any circuit breaker used to protect the circuit.

3.2 Insulated systems

3.2.1 In insulated systems, the source of power is insulated from earth or connected to the earthed through a sufficiently high impedance.

3.2.2 Every insulated distribution system, whether primary or secondary (see Note 1), for power, heating or lighting, is to be provided with suitable means to monitor the insulation level to earth (i.e. the values of electrical insulation to earth).

Note 1: A primary system is one supplied directly by generators. Secondary systems are those supplied by transformers or convertors.

3.2.3 For yachts whose length is equal or exceeds 24 metres, the device required in [3.2.2] is to be capable of continuously monitoring the insulation level to earth and of giving an audible and visual indication of abnormally low insulation values.

3.2.4 In insulated systems, it is permissible for a single fault between a live part and an exposed conductive part to occur without automatic disconnection, provided that an earth monitoring device in compliance with [3.2.3] is fitted. A second fault is to result in automatic disconnection. A prospective touch voltage exceeding 50 V a.c. is not to persist for a time sufficient to cause a risk of harmful physiological effect in a person.

3.3 Specific requirements for yachts of 500 gross tonnage and over and charter yachts intended to carry more than 12 passengers

3.3.1 The distribution system is to be such that the failure of any single circuit will not endanger or impair any other essential service.

3.3.2 Where the main source of electrical power is necessary for propulsion and steering of the yacht, the main busbar is to be subdivided into at least two part which are normally connected by circuit-breakers or other approved means.

The connection of generating sets and other duplicated equipment is to be equally divided between as far as practicable.

3.4 A.c. distribution system

3.4.1 Where a.c. system is supplied by a combination of separate power sources (shore-power connection, on-board a.c. generator(s) or inverter), individual circuits are not to be capable of being energized by more than one source of electrical power at a time. The transfer from one power-source circuit to another is to be made by a means which opens all current-carrying conductors before closing the other source circuit, prevents arc-over between contacts and is interlocked by mechanical or electromechanical means. All current-carrying conductors are to be broken simultaneously when changing power source.

Note 1: Two or more three-phase generators, when properly synchronised are to be treated as one source.

3.4.2 The current consuming units are to be so grouped in the final circuits that the load on each phase will, under normal conditions, be balanced as far as possible at the individual distribution and section boards as well as the main switchboard.

3.4.3 The continuity of supply is not to be impaired by load-produced harmonic distorsion or high load charges.

3.5 D.c. distribution system supplied from batteries

3.5.1 Each battery or group of batteries is to be capable of being isolated from the d.c. system which is supplied, normally by a switch in the positive conductor. Isolation switches are to be placed in a readily accessible location as closed as practical to the battery or group of batteries, but outside the battery compartment or container.

3.5.2 Remote controlled isolation switches are admitted providing they also permit safe manual control.

3.5.3 The following systems may be connected between the isolation switch and the battery:

a) electronic devices with protected memory and protective devices such as bilge pumps and alarms, if individually protected by a circuit breaker or fuse as close as practical to the battery terminal

b) ventilation exhaust blower of engine/fuel-tank compartment if separately protected by a fuse or circuit breaker as close as practical to the battery terminal

c) charging devices which are intended to be used when the yacht is unattended (for example, solar panels, wind generator) if individually protected by a fuse or circuit beaker as close as practical to the battery terminal.

3.5.4 The minimum continuous rating of the battery selection/isolation switch is to be at least equal to the maximum current for which the main circuit breaker is rated and also the intermittent load of the starter motor circuit, or the current rating of the feeder conductor, whichever is less.

3.5.5 For systems where both positive and negative conductors are isolated from earth, double pole switches are to be used.

3.6 Shore connection

3.6.1 Where a yacht requires connection of an a.c. supply from shore, a suitable shore supply inlet is to be installed on the yacht for the connection of the flexible cable(s) to the shore supply outlet socket.

3.6.2 The flexible shore power cable is to be provided with the following connecting arrangements:

a) a plug conforming to IEC 60309-1 or 60309-2 to connect to the shore supply socket outlet

b) a flexible cable in compliance with IEC 60245 or equivalent, permanently connected to the yacht.

Note 1: For yacht whose length is less than 24 metres, flexible cable may be connected to a plug conforming to IEC 60309-2 to connect to a shrouded male type socket inlet onboard the yacht.

3.6.3 Adequate means are to be provided to equalise the potential between the hull and the shore when the electrical installation of the yacht is supplied from shore.

3.6.4 The shore supply inlet is to be protected against overcurrent. The protective device is to simultaneously open all unearthed current carrying conductors and the neutral conductor. The earthing conductor required in [3.6.3] is not to be interrupted by operation of the overcurrent protection device.

3.6.5 For yachts with earthed neutral system, refer to [3.1.3].

3.6.6 For yachts which are fitted with an a.c. generation supplying onboard systems, an interlocked change-over switch is to be provided to prevent parallel connection between the shore power supply and the onboard generation. The change-over switch is to be of a type suitable for isolation and must include all phases and neutral if necessary.

3.6.7 The shore connection is to be provided with an indicator on the main switchboard in order to show when the cable is energised at the correct voltage.

3.6.8 Means are to be provided for checking the polarity or the phase sequence (for three-phase a.c.) of the incoming supply in relation to the yacht's system.

3.6.9 A permanently mounted waterproof warning sign is to be located at the intake point on the yacht giving full information on the system of supply, the nominal voltage and frequency of the yacht's system and the procedure for carrying out the connection. Information on the phase sequence for three phase a.c. systems is also to be given for three phase connections.

3.7 Supply of motors

3.7.1 A separate final circuit is to be provided for every motor required for an essential service and for every motor rated at 1 kW or more.

3.7.2 Each motor is to be provided with controlgear ensuring its satisfactory starting.

Direct on line starters are accepted if the voltage drop does not exceed 15% of the network voltage.

3.8 Power supply to lighting installations

3.8.1 Final circuits for lighting supplying more than one lighting point and for socket-outlets are to be fitted with protective devices having a current rating not exceeding 16 A.

3.8.2 An main electric lighting system supplied from the main source of electrical power is to be provided throughout those of the yacht normally accessible to and used by crew or passengers.

3.8.3 In spaces such as:

a) main and large machinery spaces

b) public spaces

c) passageways

d) stairways leading to boat-decks,

the lighting circuits, including -where required- those for emergency lighting, are to be distributed so that a total blackout cannot occur due to the failure of any single final circuit.

3.8.4 The arrangement of the main lighting system of yachts of 24 metres and over is to be such that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard, will not render inoperative the emergency electric lighting system other than those located within spaces where the fire or casualty has occurred, and vice versa.

3.9 Navigation and signalling lights

3.9.1 Navigation lights are to be connected separately to a dedicated distribution board placed in an accessible position on the yacht and directly supplied from the main source of power.

3.9.2 Each navigation light is to be controlled and protected in each insulated pole by a double-pole switch and a fuse or, alternatively, by a double-pole circuit-breaker, fitted on the distribution board referred to in [3.9.1].

3.9.3 For yachts whose length is equal to or exceeds 24 metres, the following additional requirements are to comply with:

a) Provision is to be made at position mentioned in [3.9.1] to connect the navigation lights distribution board to the emergency source of power by means of a separate feeder and a manual or automatic changeover switch.

b) When it is not possible to visually observe the operation of the navigation lights from the yacht's deck, such lights are to be provided with an automatic indicator giving audible and/or visual warning in the event of failure of a navigation light.

   If a visual signal connected in series with the navigation light is used, means is to be provided to prevent the extinction of the navigation light due to the failure of the visual signal.

3.10 General alarm - Public address

3.10.1 Yachts of 24 metres and over are to be equipped with a system enabling the general broadcast of an alarm. This alarm may consist of the yacht's whistle or siren, provided it can be heard in all parts of the yacht.

3.10.2 For yachts of 500 gross tonnage and over or charter yachts intended to carry more than 12 passengers, the system required in [3.10.1] is to be supplemented by an electrically operated bell or klaxon system, powered from the yacht's main source of electrical power and also the emergency source of electrical power.

3.10.3 For yachts of 85 metres in length and over and charter yachts intended to carry more than 12 passengers, in addition to the requirements specified in [3.10.1], a public address system or other effective means of communication enabling simultaneous broadcast of messages from the navigation bridge to all spaces where people onboard are normally present (accommodation, open decks, public and machinery spaces) is to be provided. This system is to be powered from the yacht's main source of electrical power and the emergency source of electrical power.

Where an individual loudspeaker has a device for local silencing, an override arrangement from the control station, is to be in place.

3.11 Internal communications

3.11.1 Yachts whose length is equal to or exceeds 24 metres are to be fitted with an appropriate and reliable means of communication between:

a) the navigation bridge and any other position from which the speed and direction of thrust of the propeller may be controlled

b) the navigation bridge and steering gear compartment.

Note 1: These means of communication may be portable for yachts whose length is less than 24 metres.

3.11.2 Yachts of 500 gross tonnage and over and charter yachts intended to carry more than 12 passengers are to be provided with at least two independent means for communicating orders from the navigation bridge to the position in the machinery space from which the speed and direction of thrust of the propeller may be controlled. One of these is to be an engine-room telegraph which provides visual indication of the orders and responses both in the machinery spaces and on the navigation bridge. The second means of communication may be that required in [3.11.1].

3.12 Bilge level alarms

3.12.1 Alarm is to be given to the navigating bridge in case of flooding into the machinery space of category A or engine spaces situated below the load line.

3.13 Specific requirements for special power services of yachts of 24 m and over

3.13.1 The motors driving ventilating fans and fuel pumps are to be provided with remote control located outside the concerned rooms so that they can be stopped in the event of fire in the room where they are located.

3.13.2 The means provided for stopping the power ventilation of the machinery spaces are to be entirely separate from the means provided for stopping ventilation of other spaces.

3.13.3 For the supply and characteristics of the distribution of the following services, see requirements listed in:

a) fire extinguishing systems: Ch 4, Sec 13, as applicable

b) fire detection systems: Ch 4, Sec 13, [6.1.2]

c) steering gear: Ch 1, Sec 3, [2.3].

3.14 Main engine starting system

3.14.1 Yachts in which the only means of propulsion is an internal combustion engine with electric starting is to be provided with two batteries or group of batteries, each one of sufficient capacity for ensuring at least the six consecutive start attempts of the main propulsion engine.

3.14.2 For yachts of less than 500 gross tonnage fitted with one propulsion engine, one battery or group of batteries is to be reserved for the engine starting device, the other may be used for supplying the yacht's electrical services. Capacity of starting batteries used for supplying other services is to be designed accordingly.

It is to be possible to select which battery or group of batteries is used for which service and also to connect both battery groups in parallel in an emergency to assist engine start.

Note 1: Service selection function may be combined with the isolation function required in [3.5.1].

3.14.3 For yachts fitted with two main propulsion engines with electric starting device, each main engine may be equipped with only one starting battery, provided that each battery is capable of being connected via a changeover switch and fixed cables to the starting system of the other main engine. The arrangement is to be such that the batteries cannot be connected in parallel.

3.14.4 Provision is to be made to maintain the stored energy of starting batteries at all times.

3.15 Specific requirements for yachts with electric propulsion

3.15.1 For yachts propelled by at least one electric propulsion motor and its electrical supply, all electrical components of the propulsion plant will be specially considered by the Society according to the requirements specified in NR467 Rules for Steel Ships, Pt C, Ch 2, Sec 14.

3.16 Lightning protection

3.16.1 Lightning protection is to be provided as follows:

a) Non metallic hull yachts are to be provided with lightning conductor. The lower end of the lightning conductor is to be connected to an earthing plate of copper or other conducting material compatible with sea water, not less than 0.25m^2 in surface area, secured to the outside of the hull in an area reserved for this purpose and located below the light-load water line so that it is immersed under all conditions of heel. The earthing plate for the lightning conductor is to be additional to, and separate from, the earthing plate required in Ch 2, Sec 4, [2.4.2].

   For sailing yachts, metallic strays and shrouds, metallic masts, and sail tracks on non-metallic masts are to be earthed.

b) In metallic hull yachts fitted with non-metallic masts, a lightning conductor is to be provided. The lower end of the lightning conductor is to be earthed to the hull.

   For sailing yachts, the metallic sail tracks are to be also earthed.

c) In metallic hull yachts, if there is electrical continuity between hull and lightning protective masts or other metallic superstructure of adequate height, no additional lightning protection is required.

Note 1: For yachts less than 24 m in length, ISO 10134 may be used for guidance.

3.16.2 Lightning conductors are to be made of copper (strip or stranded) and are not to be less than 70 mm^2 in cross-section. They are to be secured to a copper spike not less than 12 mm in diameter, projecting at least 300 mm above the top of the mast. The lower end of the conductor is to be earthed.

3.16.3 Lightning conductors are to be installed external to the yacht and should run as straight as possible. Sharp bends are to be avoided.

3.16.4 Only bolted, riveted or welded joints are to be used.

4 Degrees of protection of equipment and enclosures

4.1 General

4.1.1 Energized parts of electrical equipment are to be guarded against accidental contact by the use of enclosures. Access to energized parts of the electrical system is to require the use of hand tools or have a protection of at least IP2X. Depending on its location, electrical equipment is to have, as a minimum, the degree of protection specified in Tab 2.

4.1.2 In addition to the requirements of this paragraph, equipment installed in spaces with an explosion hazard is also subject to the provisions in [8.1.1].

4.1.3 Wherever possible, cable entries are to be positioned on the bottom of equipment and enclosures and are to have an IP rating equal to that of the equipment enclosure.

If location of cable entries on the sides or top of an enclosure is unavoidable, they are not to alter the IP of the equipment enclosure.

Table 2 : Minimum required degrees of protection

Example of location	Switchboard and control gear	Generators	Motors	Transformers	Luminaries	Instrument	Switches	Accessories
Dry accommodation spaces Closed navigation bridge	IP 20	–	IP 20	IP 20	IP 20	IP20	IP 20	IP 20
Steering gear room (above floor) Control rooms	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44
General store Provision rooms	–	–	IP 22	–	IP 44	–	IP 44	IP 44
Bathrooms and/or showers	–	–	–	–	IP 44	–	IP 55	IP 55
Engine (above floor)	IP 22	IP 22	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44
Damp or humid spaces	IP 44	IP 44	IP 44	–	IP 44	IP 44	IP 55	IP 55
Ventilation ducts	–	–	IP 22	–	–	–	–	–
Engine room (below floor)	–	–	IP X8	–	IP X8	IP X8	IP X8	–
Galleys and laundries	IP 44	–	IP 44	IP 44	IP 44	IP 44	IP 44	IP 44
Open decks	IP 56	–	IP 56	–	IP 56	IP 56	IP 56	IP 56
Note 1: Electrical equipment is not to be installed below floor plates in engine rooms, except as indicated above.								

4.1.4 Socket outlets installed in locations subject to rain, spray or splashing (open deck) are to be IP56 or to enclosed in IP 56 enclosures, as a minimum, when not in use. When the appropriate plug is connected the outlet is to maintain IP56.

4.1.5 Socket outlets installed in areas subject to flooding or momentary submersion are to be in IP67 enclosure, as a minimum, also maintaining IP67 when an appropriate plug is inserted.

5 Diversity (demand) factors

5.1 General

5.1.1 The cables and protective devices of final circuits are to be rated in accordance with their connected load.

5.1.2 Circuits supplying two or more final circuits are to be rated in accordance with the total connected load subject, where justifiable, to the application of a diversity (demand) factor in accordance with [5.1.3] and [5.1.4].

Where spare-circuits are provided on a section or distribution board, an allowance for future increase in load is to be added to the total connected load, before the application of any diversity factor. The allowance is to be calculated on the assumption that each spare circuit requires not less than the average load on each of the active circuits of corresponding rating.

5.1.3 A diversity (demand) factor may be applied to the calculation of the cross-sectional area of conductors and to the rating of switchgear, provided that the demand conditions in a particular part of an installation are known or may reasonably be anticipated.

5.1.4 The diversity factor applied for motor power circuits is to be determined according to the circumstances. The normal full-load is to be determined on the basis of the name-plate rating.

6 Electrical protection

6.1 Protection against overcurrent

6.1.1 Every circuit is to be protected against overload and short circuit by a fuse or circuit-breaker.

Note 1: An overcurrent is a current exceeding the nominal current.

Note 2: A short-circuit is the accidental connection by a relatively low resistance or impedance of two or more points in a circuit which are normally at different voltages.

Note 3: Overload is an operating condition in an electrically undamaged circuit which causes an overcurrent.

6.1.2 Selection, arrangement and performance of the various protective devices are to provide complete and coordinated automatic protection to ensure, as far as possible:

- the continuity of service so as to maintain, through coordinated and discriminative action of the protective devices, the supply of circuits not directly affected by a fault
- elimination of the effect of faults to reduce damage to the system and the hazard of fire as far as possible.

6.1.3 Devices provided for overload protection are to have a tripping characteristic (overcurrent-trip time) adequate for the overload ability of the elements of the system to be protected and for any discrimination requirements.

6.1.4 Each overcurrent protective device is to be selected such that:

a) its nominal current or current setting is not less than the design current of the circuit

b) its nominal current or current setting does nor exceed the lowest current-carrying capacity of any of the conductors in the circuit

c) the overload current causing operation does not exceed 1,45 times the lowest current carrying capacity of any of the conductors of the circuit

d) its rated short-circuit breaking and making capacity are equal to or in excess of, the calculated short-circuit current at the point at which the device is installed. If the short-circuit breaking or making capacity is less, then the protective device is to be backed up by a fuse or circuit breaker in accordance with IEC 60092-202.

6.1.5 The protection of the emergency circuit is to be such that a failure in one circuit does not cause a loss of other emergency services.

6.1.6 The use of fuses up to 320 A for overload protection is permitted. When fuses are used, spare fuses are to be available onboard the yacht.

6.1.7 Circuit-breakers and fuses are to be of a type approved by Society in accordance with the appropriate IEC publications.

6.2 Localisation of protection

6.2.1 Short-circuit protection is to be provided for every non-earthed conductor.

6.2.2 Overload protection is to be provided for every non-earthed conductor; nevertheless, in insulated single-phase circuits or insulated three-phase circuits having substantially balanced loads, the overload protection may be omitted on one conductor.

6.2.3 Overcurrent and fault current protective devices are not to interrupt protective conductors.

6.2.4 Electrical protection is to be located as close as possible to the origin of the protected circuit.

6.3 Protection of generators

6.3.1 DC or AC generators are to be protected against short-circuits and overloads by multipole circuit-breakers.

Note 1: The positive conductors of output circuits of self limiting DC generators and battery chargers not exceeding 2 kW do not require fuses or circuit breakers.

6.3.2 For generators with a rated output equal or less than 50 kVA which are not arranged to operate in parallel, a multipole switch with a fuse in each insulated phase on the generator side may be accepted.

Fuse rating is to be maximum 110% of the generator rated current and the trip of contactor is to be short-time delayed, with a maximum delay of 500 ms.

6.3.3 Generators of more than 50 kW d.c. or 50 kVA a.c. are to be provided with circuit-breaker in its output fitted with each of the following:

a) thermal overload protection (for example, 15 s)

b) short-circuit protection (for example, 500 ms)

c) time-delayed under voltage release (for example, 500 ms).

Note 1: Thermal devices are not to be used for generator over-current protection.

Note 2: Undervoltage protection should trip the breaker if the voltage falls to 70%-35% of the rated voltage and prevent the closing of the circuit-breaker if the generator voltage does not reach a minimum of 85% of the rated voltage.

6.3.4 Generators intended for parallel operation are to be provided with reverse power protection. The tripping of the generator circuit-breaker is to be time delayed (for example, 5 s to 15 s).

Note 1: Recommended value to be considered for the setting of the reverse-power protection: 8-15%.

6.3.5 For emergency generators the overload protection may, instead of disconnecting the generator automatically, give a visual and audible alarm in permanently attended space (for example, navigation bridge).

6.3.6 For yachts of 500 gross tonnage and over and charter yachts intended to carry more than 12 passengers where the main source of electrical power is necessary for the propulsion of the ship, load shedding or other equivalent arrangements are to be provided to protect the generators against sustained overload.

Load shedding is to be automatic and should concern non-essential loads only.

An visual and audible alarm is to be activated at the navigation bridge in case of load shedding.

6.4 Protection of final circuits

6.4.1 Each final circuit connected to a distribution board or switchboard is to be protected against overload and short-circuit by multipole circuit breaker or switch and fuses on each non-earthed conductors, unless otherwise specified in these Rules or where the Society may exceptionally otherwise permit it.

6.4.2 For yachts whose length is less than 24 metres, a protective device (fuse, circuit-breaker or RCD) is to automatically disconnect the supply to the circuit or equipment in the event of a fault between a live part and an exposed non-current-carrying conductive part.

Note 1: On yacht with relatively small single phase a.c. electrical installations powered intermittently from a shore supply, a single RCD protecting the whole of the yacht's a.c. system is commonly fitted. It should be noted that not every marina or boat yards have RCD protected shore power outlets as standards. The residual current device is to have a rated residual operating current not exceeding 30 mA and an operating time not exceeding 40 ms at a residual current of 150 mA.

6.4.3 Final circuits which supply one consumer with its own overload protection (for example motors) or consumers which cannot be overloaded (for example permanently wired heating circuits and lighting circuits), may be provided with short-circuit protection only.

6.4.4 In both earthed neutral systems and insulated neutral systems, final circuits particularly to locations in confined or exceptionally damp spaces where an increased risk of personal contact with live conductive parts may exist (for example, socket outlets, lighting fittings) are to be fitted with a residual-current protective device with sensitivity of 30 mA maximum to automatically disconnect the supply in the event of a fault between a live part and an exposed non-current carrying conductive part.

6.4.5 Circuits for lighting are to be disconnected on both non-earthed conductors. Single pole disconnection of final circuits with both poles insulated is permitted only in dry accommodation spaces when a residual-current protective device with sensitivity of 30mA is provided or when circuit is supplied at a voltage not exceeding the safety voltage.

6.5 Protection of motors

6.5.1 Motors of rating exceeding 1 kW and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection may be provided by the same protective device for the motor and its supply cable (see [6.4.3]).

6.5.2 Where necessary, motors rated above 1 kW are to be provided following additional protections:

- locked rotor
- unbalanced phase
- thermal image
- under-voltage.

6.5.3 For motors intended for essential services, the overload protection may be replaced by an overload alarm (for steering gear motors see Ch 1, Sec 3, [2.3.5]).

6.5.4 The protective devices are to be designed so as to allow excess current to pass during the normal accelerating period of motors according to the conditions corresponding to normal use.

6.5.5 The protective devices are to be adjusted so as to limit the maximum continuous current to a value within the range 105%-120% of the motor’s rated full load current.

6.6 Protection of storage batteries

6.6.1 Batteries are to be protected against overload and short-circuit by means of fuses or multipole circuit-breakers placed as closed as practicable to the batteries but outside the battery compartment or container.

Overcurrent protection may be omitted for the circuit to the starting devices when the current drawn is so large that is impracticable to obtain short-circuit protection.

6.6.2 Emergency batteries supplying essential services are to have short-circuit protection only.

6.7 Protection of transformers

6.7.1 The primary winding side of power transformers is to be protected by a against short-circuit and overload by means of a multipole circuit-breakers or switches and fuses. The protective device is to be adjusted at no more than 125% of the rated primary current of the transformer.

6.7.2 The protection against short-circuit is to be such as to ensure the selectivity between the circuits supplied by the secondary side of the transformer and the feeder circuit of the transformer.

6.8 Protection of measuring instruments, pilot lamps and control circuits

6.8.1 Measuring circuits and devices (voltmeters, insulation monitoring devices etc.) and pilot lamps are to be protected against short-circuit by means of multipole circuit-breakers or fuses.

The protective devices are to be placed as near as possible to the tapping from the supply.

6.8.2 Control circuits and control transformers are to be protected against overload and short-circuit by means of multipole circuit-breakers or fuses on each pole not connected to earth.

Overload protection may be omitted for transformers with a rated current of less than 2 A on the secondary side.

The short-circuit protection on the secondary side may be omitted if the transformer is designed to sustain permanent short-circuit current.

6.9 Special applications

6.9.1 Circuits which supply safety equipment, such as radio, navigation and navigational aids, are to be individually protected against short-circuits by means of circuit-breakers or fuses. These circuits are to be clearly identified.

7 Electrical cables

7.1 General

7.1.1 Cables and insulated wiring are to be constructed in accordance with IEC Publications of the series 60092-3, and normally of a type approved by the Society.

Cable and insulated wires other than those specified in IEC Publications are subject to special consideration by the Society in each case.

7.1.2 All electrical cables and wiring external to equipment are to be at least of a flame-retardant type, in accordance with IEC Publication 60332-1.

7.1.3 In addition to the provisions of [7.1.2], when cables are laid in bunches, cable types are to be chosen in compliance with IEC Publication 60332-3-22 Category A.

7.1.4 Where necessary for specific applications such as radio frequency or digital communication systems, which require the use of particular types of cables, the Society may permit the use of cables which do not comply with the provisions of [7.1.2].

7.1.5 Flexible cables constructed according to national standards are to be specially considered by the Society.

7.2 Conductors

7.2.1 Conductors are to be stranded and of annealed electrolytic copper according to IEC 60092-350. In yachts of aluminium construction, conductors are to conform at least to Class 2 upstream of transformers to avoid functioning as an earth electrode.

7.3 Choice of protective covering

7.3.1 Cables fitted on decks exposed to the weather, in damp and wet locations (for example, bathroom), in refrigerated spaces, in machinery spaces and wherever water condensation or harmful vapour (including oil vapour) may be present, are to have a water resistant sheath.

Note 1: Polyvinyl chloride (PVC), chlorosulphonated-polyethylene (CSP) and polychloroprene (PCP) sheaths are considered as water resistant in this context, although not suitable for permanent immersion in liquids. However such sheaths are to be avoided where they are likely to come into contact with and chemically react with polyurethane foam thermal insulating material.

7.3.2 An impervious sheath is not required for single-core cables installed in tubes or ducts inside accommodation spaces, in circuits with maximum system voltage 250 V.

7.3.3 In selecting the protective covering, due consideration is to be given to the mechanical strength required to withstand handling during installation and working conditions when in service.

If the mechanical strength of the protective covering is considered insufficient, the cables are to be mechanically protected (e.g. by an armour or by installation inside pipes or conduits).

7.3.4 PVC insulated cables are not to be used on decks exposed to the weather of yachts classed for unrestricted service.

7.4 Cables for submerged bilge pumps

7.4.1 Cables and their connections to such pumps are to be capable of operating under a head of water equal to their distance below the bulkhead deck. The cable is to be impervious-sheathed and armoured and is to be installed in continuous lengths from above the bulkhead to the motor terminals.

7.5 Internal wiring of switchboards and other enclosures for equipment

7.5.1 For installation in switchboards and other enclosures for equipment, single-core cables may be used without further protection (sheath).

Other types of flame-retardant switchboard wiring may be accepted at the discretion of the Society.

7.6 Current carrying capacity of cables

7.6.1 The current carrying capacity for cables in continuous service, for various insulating materials are given in Tab 3.

The values are based on the maximum permissible service temperature of the conductor also indicated therein and on an ambient temperature of 45°C.

Note 1: For temperature class of 75°C or 85°C, refer to IEC 60092-201.

7.6.2 The current carrying capacity cited in [7.6.1] is applicable, with rough approximation, to all types of protective covering (e.g. both armoured and non-armoured cables).

7.6.3 When the actual ambient temperature obviously differs from 45°C, the correction factors shown in Tab 4 may be applied to the current carrying capacity in Tab 3.

7.6.4 Where more than six cables are bunched together in such a way that there is an absence of free air circulating around them, and the cables can be expected to be under full load simultaneously, a correction factor of 0,85 is to be applied.

7.6.5 Where a cable is intended to supply a short-time load for 1/2-hour or 1-hour service (e.g. mooring winches or bow thruster propellers), the current carrying capacity obtained from Tab 3 may be increased by applying the corresponding correction factors given in Tab 5.
In no case a period shorter than 1/2-hour is to be used, whatever the effective period of operation.

7.7 Minimum nominal cross-sectional area of conductors

7.7.1 In general the minimum allowable conductor cross-sectional areas are those given in Tab 6.

7.7.2 The nominal cross-sectional area of the neutral conductor in three-phase distribution systems is to be equal to at least 50% of the cross-sectional area of the phases, unless the latter is less than or equal to 16 mm^2. In such case the cross-sectional area of the neutral conductor is to be equal to that of the phase.

7.7.3 For the nominal cross-sectional area of protective conductor, see Ch 2, Sec 4, [2.3.2].

Table 3 : Current carrying capacity, for continuous service, in amps

Nominal cross section, in mm^2	Cable insulation											
	1 General purpose PVC			2 Heat resistant PVC			3 EPR and XLPE			4 Silicone rubber and mineral insulation		
	Temperature class 60°C			Temperature class 70°C			Temperature class 90°C			Temperature class 95°C		
	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores	1 core	2 cores	3, 4 cores
1,0	8	7	6	12	10	8	18	15	13	20	17	14
1,5	10	9	7	15	13	11	23	20	16	26	22	18
2,5	17	14	12	21	18	15	40	26	21	32	27	22
4,0	23	20	16	29	25	20	51	34	28	43	37	30
6,0	29	25	20	37	31	26	52	44	36	55	47	39
10	40	34	28	51	43	36	72	61	50	76	65	53
16	54	46	38	68	58	48	96	82	67	102	87	71
25	71	60	50	90	77	63	127	108	89	135	115	95
35	88	75	62	111	94	78	157	133	110	166	141	116
50	110	94	77	138	117	97	196	167	137	208	177	146
70	135	115	95	171	145	120	242	206	169	256	218	179
95	164	139	115	207	176	145	293	249	205	310	264	217
120	189	161	132	239	203	167	339	288	237	359	305	251
150	218	185	153	275	234	193	389	331	272	412	350	288
185	248	211	174	313	266	219	444	377	311	470	400	329
240	292	248	204	369	214	258	522	444	365	553	470	387
300	336	286	235	424	360	297	601	511	421	636	541	445

Table 4 : Correction factors for various ambient air temperatures

Maximum conductor temperature, in °C	Correction factors for ambient air temperature of:										
	35°C	40°C	45°C	50°C	55°C	60°C	65°C	70°C	75°C	80°C	85°C
60	1,29	1,15	1,00	0,82	–	–	–	–	–	–	–
70	1,18	1,10	1,00	0,89	0,77	0,63	–	–	–	–	–
75	1,15	1,08	1,00	0,91	0,82	0,71	0,58	–	–	–	–
85	1,12	1,06	1,00	0,94	0,87	0,79	0,71	0,61	0,50	–	–
90	1,10	1,05	1,00	0,94	0,88	0,82	0,74	0,67	0,58	0,47	–
95	1,10	1,05	1,00	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

Table 5 : Correction factors for half-hour and one-hour service

Nominal cross-sectional area, in mm²	Half-hour service	One-hour service
1 to 10	1,06	1,06
16	1,09	1,06
25	1,19	1,08
35	1,34	1,14
50	1,55	1,25

Table 6 : Minimum nominal cross-sectional areas

Service	Nominal cross-sectional area	
	external wiring, in mm²	internal wiring, in mm²
Power, heating and lighting systems	1,00	1,00
Control circuits for power plant	1,00	1,00
Control circuits other than those for power plant	0,75	0,50
Control circuits for telecommunications, measurement, alarms	0,50	0,20
Telephone and bell equipment, not required for the safety of the yacht or crew calls	0,20l	0,10
Bus and data cables	0,20	0,10

7.8 Choice of cables

7.8.1 Rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used. For a.c. systems following minimum voltage ratings are to be considered:

a) 1000 V for 120/230 V systems

b) 1000 V for 440 V three phases systems.

7.8.2 The nominal cross-sectional area of each cable is to be sufficient to satisfy the following conditions with reference to the maximum anticipated ambient temperature:

- the current carrying capacity is to be not less than the highest continuous load carried by the cable
- the voltage drop in the circuit, by full load on this circuit, is not to exceed the limits specified in [7.8.3] and [7.8.4]
- the cross-sectional area calculated on the basis of the above is to be such that the temperature increases which may be caused by overcurrents or starting transients do not damage the insulation.

Note 1: The highest continuous load carried by a cable is to be calculated on the basis of the power requirements and of the diversity factor of the loads and machines supplied through that cable.

7.8.3 For a.c. systems, the cross-sectional area of conductors are to be so determined that the voltage drop from the or emergency switchboard busbars to any point in the installation, under normal conditions of service with maximal current, does not exceed 6% of the nominal voltage.

7.8.4 For d.c. systems supplied from batteries, the voltage drop to any point in the installation is not to exceed 10% of the nominal voltage.

For circuits of navigation lights, the voltage drop is not to exceed 5% of the rated voltage under normal conditions.

For circuits to navigational equipment, communication equipment, windlass and engine starting the cross-sectional areas are to be determined to restrict the voltage drop to the minimum specified by the equipment manufacturer.

Note 1: The voltage drop in d.c. conductor(s) between the generator(s) and the batteries is not to exceed 1% of the rated voltage during charging.

7.9 Parallel connection of cables

7.9.1 Cables with conductors of cross-section less than 10 mm² are not to be connected in parallel.

Note 1: The current-carrying capacity of cables connected in parallel is the sum of the current ratings of all parallel conductors, provided that the cables have equal impedance, cross-section and rated conductor temperatures.

Note 2: Refer to the recommendations of clause 28 of IEC 60092-352 relating to special precautions for single-core cables for a.c. wiring.

8 Electrical equipment for use in explosive atmospheres

8.1 General

8.1.1 No electrical equipment is to be installed where flammable gases or vapours are liable to accumulate, such as large vented battery rooms, spaces containing petrol-powered machinery, petrol fuel tank(s), or joint fitting(s) or other connection(s) between components of a petrol system, and compartments or lockers containing LPG cylinders and/or pressure regulator, unless the Society is satisfied that such equipment is:

a) essential for operational purposes
b) of a type which will not ignite the mixture concerned
c) appropriate to the space concerned, and
d) appropriately certified for safe usage in the vapours or gases likely to be encountered by an appropriate authority according to IEC 60079 series or equivalent national standards.

Note 1: For yachts less than 24 metres in length ISO 8846, ISO 10239 and ISO 9094-1 and 2 may be applied.

8.2 Electrical installations in battery rooms

8.2.1 Only lighting fittings may be installed in compartment assigned solely to large vented storage batteries (see Ch 2, Sec 4, [4.2]).

The associated switches are to be installed outside such spaces.

Electric ventilator motors are to be outside ventilation ducts and, if within 3 m of the exhaust end of the duct, they are to be of an explosion-proof safe type. The impeller of the fan is to be of the non-sparking type.

Overcurrent protective devices are to be installed as close as possible to, but outside of, battery rooms.

8.2.2 Electrical equipment for use in battery rooms is to have minimum explosion group IIC and temperature class T1.

8.2.3 Standard marine electrical equipment may be installed in compartments assigned solely to valve-regulated sealed storage batteries.

8.3 Electrical equipment for vehicle spaces

8.3.1 In enclosed spaces and larger lockers designated for the safe carriage of petrol or similar fuel or vehicles with petrol in their tanks (e.g. jet-skis, motorcycles), all electrical equipment located up to 450 mm above the deck or within exhaust ventilation ducts is to be of a certified safe type appropriate for Zone 1 area installation with minimum explosion group IIA and temperature class T3. Refer to Ch 4, Sec 12.

Section 3 Equipment

1 General

1.1 Construction

1.1.1 All electrical apparatus is to be so constructed as not to cause injury when handled or touched in the normal manner.

1.1.2 The design of electrical equipment is to allow accessibility to each part that needs inspection or adjustment, also taking into account its arrangement on board.

1.1.3 Enclosures for electrical equipment are to be of an adequate mechanical strength and rigidity.

1.1.4 Ventilation is to be adequate to maintain the ambient temperature at or below the maximum at which the equipment is designed to operate.

1.1.5 All nuts and screws used in connection with current-carrying parts and working parts are to be effectively locked.

1.1.6 All equipment is generally to be provided with suitable, fixed terminal connectors in an accessible position for convenient connection of the external cables.

1.1.7 All electrical equipment and enclosures are to be marked with:
- manufacturer's name
- model number or designation
- electrical rating in volts and amperes or volts and watts
- phase and frequency, if applicable
- certified safe type, if applicable.

1.2 Degree of protection of enclosures

1.2.1 Electrical equipment is to be protected against the ingress of foreign bodies and water.
The minimum required degree of protection, in relation to the place of installation, is generally that specified in Ch 2, Sec 2, Tab 2.

1.2.2 The degrees of protection are to be in accordance with:
- IEC Publication No. 60529 for equipment in general
- IEC Publication No. 60034-5 for rotating machines.

1.2.3 Cable entrance are not to impair the degree of protection of the relevant enclosure (see Ch 2, Sec 2, [4.1.3]).

2 Switchboards

2.1 Design - Construction

2.1.1 Generally, switchboards or enclosures containing switchboards are to be constructed of durable, flame-retardant, moisture-resistant materials which are not subject to deterioration in the atmosphere and the temperatures to which they are likely to be exposed. In addition, mechanical features of the materials are to be suitable for the service conditions.

2.1.2 The large switchboards are to be provided with insulated handrails or handles fitted in an appropriate position at the front of the switchboard.

2.1.3 Where the aggregate capacity of generators connected to the main busbars exceeds 100 kVA, a separate cubicle for each generator is to be arranged with flame-retardant partitions between the different cubicles. Similar partitions are to be provided between the generator cubicles and outgoing circuits.

2.1.4 All parts of the switchboard are to be readily accessible for maintenance, repair or replacement. In particular, fuses are to be able to be safely inserted and withdrawn from their fuse-bases. All parts which require operation in normal use are to be placed on the front.

2.1.5 No live part is to be installed on the front of the switchboards without protection.

2.1.6 Where components with voltage exceeding the safety voltage are mounted on hinged doors, the latter are to be electrically connected to the switchboard by means of a separate, flexible protective conductor.

2.1.7 Connections for cables and busbars are to be protected against loosening due to vibration.

2.1.8 Each switch or control is to be marked to indicate its use, unless the purpose of the switch is obvious and its mistaken operation will not cause a hazardous condition. Switching devices are to be so designed and arranged that when in the off position they cannot accidentally move sufficiently to close the circuit.

2.1.9 Switchboards with both d.c. and a.c. electrical systems are to be fitted with a partition to separate the a.c. and d.c. sections from each other as mentioned in Ch 2, Sec 4, [7.2].

2.1.10 The rating of each circuit, together with the rating of the fuse or the appropriate setting of the overload protective device (circuit-breaker, thermal relay, etc.) for each circuit is to be permanently indicated at the location of the fuse or protective device.

2.2 Busbars

2.2.1 Busbars are to be dimensioned in accordance with IEC Publication 60092-302. Busbars and their connection are to be made of copper and are to be designed to withstand mechanical stresses due to short-circuit. Maximum temperature rise is to be 45°C.

2.2.2 The cross-section of neutral connection on an a.c. three-phase four wire system is to be at least 50% of the cross-section for the corresponding phases.

2.2.3 Bare busbars are to comply with the minimum clearances and creepage distances given in Tab 1.

Note 1: Clearance is the distance between two conductive parts along a string stretched the shortest way between such parts. Creepage distance is the shortest distance along the surface of an insulating material between two conductive parts.

Table 1 : Clearances and creepage distances

Rated insulation voltage, in V	Minimum clearance, in mm	Minimum creepage distance, in mm
≤ 250	15	20
> 250 to ≤ 690	20	25
> 690 to < 1000	25	35

2.3 Auxiliary circuits

2.3.1 Auxiliary circuits relative to essential services are to be designed in such a manner that, a single fault in such circuits do not impair the operation of other essential services.

2.3.2 Common auxiliary circuits for groups of consumers are permitted only when the failure of one consumer jeopardizes the operation of the entire system to which it belongs.

2.3.3 The supply of auxiliary circuits by specifically arranged control distribution systems will be specially considered by the Society.

2.4 Instruments

2.4.1 Normal full load values are to be marked in red on the instrument scale for all indicating instruments and appropriate labels are to be fixed to digital instruments when employed.

2.4.2 Instruments for d.c generators

a) Generators of 2 kW output or more, which are not operated in parallel, are to be provided with at least one voltmeter and one ammeter.

b) Generators for parallel operation are to be provided with one voltmeter for each generator (or one voltmeter and a change-over switch for its connection to each generator), one ammeter for each generator and one voltmeter for each section of busbar.

c) For compound-wound generators fitted with equalizer connections, the ammeter is to be connected to the pole opposite to that connected to the series winding of the generator.

2.4.3 Instruments for a.c. generators

a) Each a.c. generator not operated in parallel, except single-phase generators smaller than 2 kVA, is to be provided with at least:

- 1 voltmeter
- 1 ammeter in each phase or one ammeter with a selector switch which enables to read the current in each phase
- 1 frequency meter for generators rated more than 15 kVA.

b) Each a.c. generator operated in parallel is to be provided with at least:

- 1 wattmeter capable of indicating reverse power up to 15% of the rated full load of the generator
- 1 ammeter in each phase conductor (or one ammeter with a selector switch to permit the measurement of current in each phase).

For paralleling purpose, the following are to be provided:

- 2 voltmeters
- 2 frequency meters
- 1 synchronising device comprising either a synchronoscope and lamps, or an equivalent arrangement.

One voltmeter and one frequency meter are to be connected to the busbars; the other voltmeter and frequency meter are to have a selector switch to permit measurement of the voltage and frequency of any generator.

Note 1: When generators are running in parallel in installations with the neutral earthed, it is necessary to ensure that the equalising current caused by harmonics does not exceed harmful values. Reference is to be made to guidance from generator manufacturer.

2.4.4 Each secondary distribution system is to be provided with one voltmeter.

2.4.5 Switchboards are to be fitted with means for monitoring the insulation level of insulated distribution systems as stipulated in Ch 2, Sec 2, [3.2.2] and Ch 2, Sec 2, [3.2.3].

2.4.6 The main switchboard is to be fitted with a voltmeter or signal lamp indicating that the cable between the shore-connection to main switchboard is energised (see Ch 2, Sec 2, [3.6.7]).

2.4.7 For each d.c. power source (e.g. convertors, rectifiers and batteries), one voltmeter and one ammeter are to be provided, except for d.c. power sources for starting devices.

2.5 Testing

2.5.1 Switchboards are normally to be subjected to the tests specified in this Section prior installation on board.

The manufacturer is to issue the relative test reports providing information concerning the construction, serial number and technical data relevant to the switchboard, as well as results of the tests required.

a) High voltage test

The main and auxiliary circuits are to be tested with a.c. voltage given in Tab 2 and Tab 3, at a frequency between 25 and 100Hz of approximately sinusoidal form.

The test voltage is to be applied between all live parts connected together and earth or between each polarity and all the other polarities connected to earth for the tests. The prescribed test voltage is to be maintained for 1 minute.

During this test, all interrupting and protective devices are to be closed; measuring instruments and relays may however be disconnected and tested separately in accordance with the appropriate requirements.

b) Measurement of the insulation resistance

Immediately after completion of the high voltage test, the insulation resistance is to be measured using a device with a direct current voltage of at least 500 VDC. The insulation resistance between all current carrying parts and earth or between each polarity and the other polarities is to be at least equal to 1 megohm.

Table 2 : Testing voltages for main circuits

Insulation rated voltage, in V	AC test voltage (rms), in V
$U_i \leq 60$	1000
$60 < U_i \leq 300$	2000
$300 < U_i \leq 660$	2500
$660 < U_i \leq 800$	3000
$800 < U_i \leq 1000$	3500

Table 3 : Testing voltages for auxiliary circuits

Insulation rated voltage, in V	AC test voltage (rms), in V
Ui ≤ 12 12 < Ui ≤ 60	250 500
Ui > 60	2 Ui + 1000 with a minimum of 1500

3 Rotating electrical machines

3.1 General

3.1.1 Rotating machines used for essential services are to be manufactured according to recognized international or national standards.

3.2 D.C. generators

3.2.1 D.c. generators are generally alternators with integral rectifiers and regulators fitted to the propulsion machinery.

3.2.2 The voltage regulation is to be ensured with, if necessary, the use of an automatic voltage regulator, particularly in the case of generator driven by a propulsion engine.

For generators of a power higher than 20 kW and less than 50 kW, the regulation is at least such that, in case of sudden removal of half the rated load, the speed remaining constant, the voltage increase remains lower than 8% in the case of shunt wound generators and 4% in the case of compound wound generators.

3.3 A.C. generators

3.3.1 A.c generators are to comply with the relevant requirements of IEC Publication 60092-301.

3.3.2 Alternators are to be so constructed that when started up, they take up the voltage without the aid of an external electrical power source.

3.3.3 The voltage wave form is to be approximately sinusoidal, with a maximum deviation from the sinusoidal fundamental curve of 5% of the peak value.

3.3.4 Each generator is to be provided with automatic means of voltage regulation.

3.3.5 For a.c. generating sets intended to operate in parallel, means are to be provided to regulate the governor so as to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

3.3.6 For a.c. generating sets operating in parallel, the governing characteristics of the prime movers are to be such that, within the limits of 20% and 100% total load, the load on any generating set will not normally differ from its proportionate share of the total load by more than 15% of the rated power in kW of the largest machine or 25% of the rated power in kW of the individual machine in question, whichever is the lesser.

3.3.7 When a.c. generators are operated in parallel, the reactive loads of the individual generating sets are not to differ from their proportionate share of the total reactive load by more than 10% of the rated reactive power of the largest machine, or 25% of that of the smallest machine, whichever is the lesser.

3.3.8 The combined prime mover, transmission system and generator are to be designed to withstand without damage the effects of the most onerous short-circuit condition at the generator terminals when running at rated voltage and speed.

3.4 Prime movers, speed control

3.4.1 Prime movers for driving generators are to comply with the relevant requirements of Ch 1, Sec 2, [2].

3.4.2 When generators are to operate in parallel, the characteristics of speed governors are to comply with [3.3.6] and [3.3.7].

3.4.3 The generators driven by the propulsion engine, by a geared shaft or by an auxiliary set intended for another purpose, are to be designed with consideration of the modifications of the number of revolutions which may occur in service.

3.5 Testing

3.5.1 All machines of 100 kW and over, intended for essential services are to be type approved or case-by-case approved and surveyed by the Society during testing and, if appropriate, during manufacturing. Tested machines are to be individually certified by the Society.

Note 1: An alternative inspection scheme may be agreed by the Society with the manufacturer whereby the attendance of the Surveyor will not be required as indicated above.

3.5.2 All machines of less than 100 kW intended for essential services are to be type approved or manufactured according to recognized international or national standards.

Individual works' certificate is to be issued by the manufacturer and detailed test report submitted to the Society.

3.5.3 For rotating machines intended for non-essential services, individual works' certificate and detailed test report are to be made available and submitted upon request.

3.5.4 All tests are to be carried out according to IEC Publication 60092-301.

4 Transformers

4.1 General

4.1.1 Transformers used for power, lighting and as static convertors, starting transformers, static balancers, saturable reactors and transductors, including single-phase transformers rated at less than 1kVA, and three-phase transformers rated at less than 5 kVA, are to comply with IEC 60092-303.

Transformers complying with other recognized international standards will be specially considered y the Society.

4.2 Construction

4.2.1 Transformers with liquids containing polychlorinated biphenyl's (PCB) are not to be used.

4.2.2 Transformers, except those for motor starting, are to be double wound (two or more separate windings).

4.2.3 Transformers are normally to be of the dry, air cooled type. When a forced air cooling system is used, an alarm is to be activated in the event of its failure.

4.2.4 Transformers are to have enclosures with a degree of protection in accordance with Ch 2, Sec 2, Tab 2.

4.3 Testing

4.3.1 All transformers intended for essential services are to be tested by the manufacturers. The manufacturer is to issue a test reports giving, inter alia, information concerning the construction, type, serial number, insulation class and all other technical data relevant to the transformer, as well as the results of the tests required.

Such test reports are to be made available to the Society.

4.3.2 Tests of transformers of 100 kW and over (60 kVA when single phase) intended for essential services are to be attended by a Surveyor of the Society in accordance with an approved procedure.

4.3.3 Tests are to be carried out according to the requirements of IEC 60076 and 60726.

5 Converters/inverters

5.1 General

5.1.1 Converters/inverters are to comply with the relevant requirements of IEC Publication 60092-304.

Converters/inverters complying with other recognized international standards will be specially considered by the Society.

5.2 Construction

5.2.1 Converters/inverters are to be so constructed that they may be removed without dismantling the complete unit.

5.2.2 Natural air-cooling units are to be designed with sufficient ventilation openings, or with sufficient cooling surface to dissipate the heat so that totally enclosed equipment operates within the design temperature limits.

6 Storage batteries and chargers

6.1 Constructional requirement for batteries

6.1.1 The requirements of this Article apply to permanently installed storage batteries (not portable batteries).

6.1.2 Vented batteries are to be constructed to withstand the movement of the yacht and the atmosphere (e.g. salt mist) to which they may be exposed. No spillage of electrolyte is to occur at any inclination angle up to 45° from the vertical.

6.1.3 Battery terminal connectors which depend on spring tension for mechanical connection to the terminal are not to be used.

6.2 Constructional requirement for chargers

6.2.1 Chargers are to be adequate for the batteries for which they are intended.

6.2.2 Chargers are to incorporate a voltage regulator and a charge indicator. Protection against overcharging and reversal of the charging current are to be provided.

6.2.3 Battery chargers are to be constructed to simplify the maintenance operation. Indications are to be provided to visualise the proper operation of the charger and for troubleshooting.

6.2.4 The charging facilities for batteries are to be such that the completely discharged battery may be charged to 80% charge within a period of 10 hours without exceeding the maximum permissible charging current and having due regard for service requirements.

6.2.5 Charge regulators used with a wind generator or photo-voltaic cells are to be specially designed for use in such systems. When used to charge battery installations, they are to be set so that the gassing voltage of the battery to which they are connected cannot be exceeded.

7 Accessories

7.1 Plugs and socket-outlets

7.1.1 Where an earthed system is used, plug and socket outlets of the earthing type are to be arranged with a terminal provided for the protective conductor.

7.1.2 Socket-outlets rated over 16 A are to be normally provided with a switch.

7.1.3 Where socket-outlets are supplied at different voltages, the socket-outlets and plugs are to be designed in a such a way that an incorrect connection cannot be made.

7.1.4 Socket outlets and matching plugs used on d.c. systems are to be to be different from and not to be interchangeable with those used in the a.c. system on the yacht.

7.2 Lighting fittings

7.2.1 Lighting fittings are to comply with IEC Publications 60092-306.

Lighting fittings complying with other standards are to be specially considered by the Society.

7.2.2 Lighting fittings likely to be exposed to risk of mechanical damage are to be either protected against such damage or to be specially robust construction. The construction and installation of luminaires are to be appropriate to their location and environment.

7.3 Electrical heating and cooking appliances

7.3.1 Electrical heating and cooking appliances are to comply with the relevant requirements of IEC 60092-307.

7.3.2 The casing or enclosure of space heaters is to be so designed that clothing or other flammable material cannot be placed on them.

7.3.3 The temperature of the external surface of space heaters is not to exceed 60°C.

7.3.4 Space heaters are to be provided with a temperature limiting device without automatic reconnection which automatically trips all poles or phases not connected to earth when the temperature exceeds the maximum permissible value.

7.3.5 Live parts of cooking appliances are to be protected such that any foods or liquids which boil over or spill do not cause short-circuits or loss of insulation.

Section 4 Installation

1 General

1.1 Protection against injury or damage caused by electrical equipment

1.1.1 All electrical equipment is to be so installed as not to cause injury when handled or touched in the normal manner.

1.1.2 All electrical equipment is to be installed in such a way that live parts cannot be inadvertently touched, unless supplied at a safety voltage.

1.1.3 For protective earthing as a precaution against indirect contact, see [2].

1.1.4 Equipment is to be installed so as not to cause, or at least so as to reduce to a minimum, electromagnetic interference.

1.2 Protection against damage to electrical equipment

1.2.1 Electrical equipment is to be so placed that as far as practicable it is not exposed to risk of damage from water, oil or oil vapours.

1.2.2 Enclosures for electrical equipment are to be mounted so that the equipment will not be affected by the distortions, vibrations and movements of the yacht's structure that occur during normal operation of the yacht.

1.2.3 If electrical fittings are attached to structures of another metal, for instance aluminium, suitable provision is to be made to prevent galvanic corrosion.

1.3 Accessibility

1.3.1 Equipment is to be so installed that sufficient space is available for inspection and maintenance as required for all its parts.

2 Earthing of non-current carrying parts

2.1 General

2.1.1 The purpose of earthing and bonding of non-current-carrying parts of an electrical system is to reduce the danger of shock to personnel and to minimise damage to equipment from the effects of earth currents. These can occur from failures of insulation of live conductors, induced voltages and currents.

2.2 Parts which are to be earthed

2.2.1 All exposed non-current carrying conductive parts of both fixed and portable electrical machines or equipment which are liable under fault conditions to become live and similar parts inside non-metallic enclosures are to be connected to earth unless the machines or equipment are:

a) supplied at a voltage not exceeding 50 V direct current or 50 V root mean square between conductors, achieved without the use of auto-transformers (safety voltage), or
b) supplied at a voltage not exceeding 250 V by safety isolating transformers supplying only one consuming device only, or
c) constructed in accordance with the principle of double insulation (Class II) as per IEC 60536 or equivalent insulation intended to prevent the appearance of dangerous voltages on its accessible parts due to a fault in the basic insulation.

2.3 Earthing connection

2.3.1 All exposed non-current carrying conductive parts are to be connected to earth either via the protective conductors (which may be separate from neutral conductor (TN-S) or not separate (TN-C)) or by direct connection to the hull for metallic yachts.

2.3.2 The nominal cross-sectional area of bonding and protective conductors is to be not less than that required in Tab 1.

Note 1: Precautions are to be taken for design of cross-sectional area of protective conductors for components producing harmonic distortion.

Table 1 : Cross-sectional area of protective and bonding conductors

Type of earthing connection		Cross-sectional area of associated current carrying conductor	Minimum cross-sectional area of copper earthing connection
1	Protective conductor in flexible cable or flexible cord	any	Same as current carrying conductor up to and including 16 mm^2 and one half above 16 mm^2 but at least 16 mm^2
2	Protective conductor incorporated in fixed multicore cable	any	a) a cross-section equal to that of the main conductors if the latter is less than or equal to 16 mm^2, subject to a minimum of 1,5 mm^2 b) a cross-section of not less than 50% of the cross-section of the main conductor when the latter is more than 16 mm^2, but at least 16 mm^2
3	Protective conductor provided by single core cable	any	a) a cross-section equal to that of the current carrying conductor if the latter is less than or equal to 16 mm^2 b) a cross-section of not less than 50% of the cross-section of the current carrying conductor if the latter is more than 16 mm^2, but at least 16 mm^2
4	Separate fixed bonding conductor	> 1,5 mm^2 but ≤ 120 mm^2	One half the cross-sectional area of the current carrying conductor, subject to a minimum of 2,5 mm^2
		> 120 mm^2	70 mm^2

2.4 Earthed distribution system

2.4.1 The a.c. protective conductor(s) are to be provided with a final connection to the hull for metallic hull yachts or to the external main earthing plate required in [2.4.2] for yachts with non metallic hull.

Connection is to be effected at one point only by means independent of any earthing arrangements of non-current carrying parts.

On larger yachts a main earth conductor bar may be used to connect all protective conductors at one location before the final connection is made.

2.4.2 Earthing of non metallic hull yachts is to be made by an external earthing plate of copper or other conducting material compatible with sea water, and having a surface area of not less than 0,25 m^2. This plate is to be secured to the outside of the hull in an area reserved for this purpose and located below the light-load water line so that it is immersed under all conditions of heel.

Note 1: For metallic yachts, and particularly those of aluminium alloy, control systems of internal combustion engines are to be insulated from engine earth.

2.4.3 The earthing connection is to be made at a location above any anticipated water accumulation in an accessible position where it may readily be inspected and disconnected for insulation testing.

2.5 Bonding connections

2.5.1 The earth bonding is to be such as to give substantially equal potential and sufficiently low earth fault loop impedance to ensure correct operation of protective devices.

2.5.2 Every earthing conductor is to be made of copper or other corrosion-resistant material and is to be securely installed and protected, where necessary, against damage and electrolytic corrosion.

2.5.3 Extraneous conductive parts which are connected to hull of a steel yacht by permanent and reliable metal to metal joints of negligible impedance need not be bonded by separate earthing conductors.

2.5.4 All bonding conductors for a.c. and d.c. installations are to be identified by green with yellow stripes insulation or may be uninsulated. Conductors with green with yellow stripes insulation are not to be used for current-carrying conductors.

2.5.5 Metals used for earth or earth bond terminal studs, nuts and washers are to be corrosion-resistant and galvanically compatible with the conductor and terminal. Aluminium and unplated steel are not to be used for studs, nuts and washers in electrical circuits. No more than four conductors are to be secured to one earth or earth bond one terminal stud.

2.5.6 For yachts of 24 metres and over, the means of bonding, where possible, is to be separate from that provided at the yacht hull for radio, radar and communication circuits to minimise possible interference.

3 Converters - Transformers

3.1 Semiconductor power converters

3.1.1 Converters/inverters are to be installed such that the circulation of air around them is not impeded and so that the air temperature at their cooling inlet air does not exceed the ambient temperature.

3.1.2 Converters/inverters are not to be mounted near sources of heat such as engine exhaust pipes.

3.2 Transformers

3.2.1 Transformers are to be installed in well-ventilated locations. Their connections are to be protected against mechanical damages, condensation and corrosion as may be reasonably expected.

4 Storage batteries

4.1 General

4.1.1 Batteries are to be located where they are not exposed to excessive heat, extreme cold, spray, steam or other conditions which would impair performance or accelerate deterioration. They are to be installed in such a way that no damage may be caused to surrounding appliances by the vapours generated.

4.1.2 Batteries are to be secured against movements and inclinations occurring during yacht operation.

On sailing yachts, and small motor yachts, batteries are to be secured sufficiently to prevent them from breaking free in the event of a complete capsize (i.e. inversion).

4.1.3 Where vented batteries are fitted in machinery spaces, drip trays or containers resistant to the effects of the electrolyte are to be provided.

4.1.4 Starter batteries are to be located as close as practicable to the engine or engines served.

4.1.5 Lead-acid batteries and alkaline batteries are not to be installed in the same compartment (room, container, box), unless of valve-regulated sealed type.

4.1.6 Batteries are not to be installed directly above or below a fuel tank or fuel filter and any other metallic component of the fuel system within 300 mm above the battery top, as installed is to be electrically insulated.

4.1.7 Switches and fuses or other equipment, which may generate sparks are not to be placed in battery compartments.

4.1.8 Batteries are not to be located in sleeping quarters except where hermetically sealed to the satisfaction of the Society.

4.2 Large vented batteries

4.2.1 Batteries connected to a charging device of power exceeding 2 kW, calculated from the maximum obtainable charging current and the nominal voltage of the battery (hereafter referred to as "large batteries") are to be installed in a room assigned to batteries only.

Where this is not possible, they may be arranged in a suitable locker on deck.

4.2.2 Rooms assigned to large batteries are to be provided with mechanical exhaust ventilation.

Natural ventilation may be employed for boxes located on open deck.

4.2.3 The provisions of [4.2.1] and [4.2.2] also apply to several batteries connected to charging devices of total power exceeding 2 kW calculated for each one as stated in [4.2.1].

4.3 Moderate vented batteries

4.3.1 Batteries connected to a charging device of power between 0,2 kW and 2 kW calculated as stated in [4.2.1] (hereafter referred to as "moderate batteries") are to be arranged in the same manner as large batteries or placed in a box or locker in suitable locations such as machinery spaces, storerooms or similar spaces. In machinery spaces and similar well-ventilated compartments, these batteries may be installed without a box or locker provided they are protected from falling objects, dripping water and condensation where necessary.

4.3.2 Rooms, lockers or boxes assigned to moderate batteries are to be provided with natural ventilation or mechanical exhaust ventilation, except for batteries installed without a box or locker (located open) in well-ventilated spaces.

4.3.3 The provisions of [4.3.1] and [4.3.2] also apply to several batteries connected to charging devices of total power between 0,2 kW and 2 kW calculated for each one as stated in [4.2.1].

4.4 Small vented batteries

4.4.1 Batteries connected to a charging device of power less than 0,2 kW calculated as stated in [4.2.1] (hereafter referred to as "small batteries") are to be arranged in the same manner as moderate or large batteries, or without a box or locker, provided they are protected from falling objects, or in a box in a ventilated area.

4.4.2 Boxes for small batteries may be ventilated only by means of openings near the top to permit escape of gas.

4.5 Ventilation

4.5.1 The ventilation of battery compartments is to be independent of ventilation systems for other spaces.

4.5.2 The quantity of air expelled (by natural or forced ventilation) for compartments containing vented type batteries is to be at least equal to:

$Q = 110 \cdot I \cdot n$

where:

Q	:	Quantity of air expelled, in litres per hour
I	:	Maximum current delivered by the charging equipment during gas formation, but not less than one quarter of the maximum obtainable charging current in amperes
n	:	Number of cells in series.

4.5.3 The ventilation rate for compartment containing valve-regulated sealed batteries may be reduced to 25% of that given in [4.5.2].

4.5.4 Ducts are to be made of a corrosion-resisting material or their interior surfaces are to be painted with corrosion-resistant paint.

4.5.5 Cable entries to battery room, compartments or containers are to be gas-tight.

4.5.6 The air inlet to battery compartments or containers is to be below the level of the battery, and the outlet is to be at the highest point of the compartment or container.

Air inlet may be from the open air or from another space (for example from machinery spaces).

4.5.7 Exhaust ducts of natural ventilation systems are:

a) to be run directly from the top of the compartment to the open air above (they may terminate in the open or in well-ventilated spaces)
b) to terminate not less than 90 cm above the top of the battery compartment
c) to have no part more than 45° from the vertical
d) not to contain appliances (for example flame arrestors) which may impede the free passage of air or gas mixtures.

Where natural ventilation is impracticable or insufficient, mechanical exhaust ventilation is to be provided.

4.5.8 In mechanical exhaust ventilation systems:

a) electric motors are to be outside the exhaust ducts and battery compartment and are to be of an explosion-proof safe type if installed within 3 m from the exhaust of the ventilation duct
b) fans are to be so constructed and of a material such as to render sparking impossible in the event of the impeller touching the fan casing
c) steel or aluminium impellers are not to be used
d) the system is to be interlocked with the charging device so that the battery cannot be charged without ventilation. A warning signal is to be provided and operate if failure occurs.

4.5.9 For natural ventilation systems for deck boxes:

a) holes for air inlet are to be provided on at least two opposite sides of the box
b) the exhaust duct is to be of ample dimensions
c) the duct is to terminate at least 1,25 m above the box in a goose-neck or mushroom-head or the equivalent
d) the degree of protection is to be in accordance with Ch 2, Sec 2, Tab 2.

5 Switchboards

5.1 General

5.1.1 Switchboards are to be so arranged as to give easy access as may be needed to apparatus and equipment, without danger to personnel.

5.1.2 An unobstructed space is to be left in front of the switchboards wide enough to allow access for operation and maintenance.

5.1.3 When the voltage exceeds the safety voltage, non-conducting mats or gratings are to be provided at the front of the switchboard and also at the rear if access to the rear is provided. The insulated mats or gratings are to be oil-resistant and non-slippery.

5.1.4 Piping and conduits are not to be installed directly above or in the vicinity of switchboards.

Where this is unavoidable, pipes and conduits are to have welded joints only or to be provided with protection against spray from pressurised liquids or dripping.

5.2 Main switchboard

5.2.1 The main switchboard shall be so placed relative to one main generating station that, as far as practicable, the integrity of the normal electrical supply may be affected only by a fire or other casualty in one space.

5.2.2 An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, is not to be considered as separating switchboards from generators.

5.3 Emergency switchboard

5.3.1 When provided, the emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power.

5.3.2 Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

6 Cables

6.1 General

6.1.1 Cables having insulating materials with different maximum permissible conductor temperatures are not to be bunched together. Where this is not practicable, the size of these cables is to be sufficient to ensure that no cable can reach a temperature higher than its rating.

6.1.2 All cables and wiring external to equipment are to be so installed as not to impair their original flame-retarding properties. To this end, only cables which have been tested in accordance with IEC Publication 60332-3 Category A or an equivalent test procedure can be installed in bunches.

6.2 Cable runs

6.2.1 Cable runs are to be as short and direct as possible, well supported, and designed to avoid areas having a increased fire risk and areas where there is a risk of mechanical damage.

6.2.2 Cables are to be routed away from exhaust pipes and other heat sources which can damage the insulation.

Note 1: The minimum clearance of the cables is 50 mm from water-cooled exhaust components and 250 mm from dry exhaust components.

6.2.3 Cables are to be routed above anticipated levels of bilge water and in other areas where water may accumulate, or at least 25 mm above the level at which the automatic bilge-pump switch activates.

6.2.4 For the installation of cables in the vicinity of radio equipment or of cables belonging to electronic control and monitoring systems, steps are to be taken in order to limit the effects of unwanted electromagnetic interference (screening and/or twisted pairs, separation).

All cables between antennas and transmitters are to be routed separately of any other cable.

6.2.5 In the case of essential services requiring a duplicate supply (e.g. steering gear circuits), the supply and associated control cables are to follow different routes which are to be as far apart as practicable, separated both vertically and horizontally.

6.2.6 Cables and wiring serving essential or emergency power, lighting, internal communications or signals are, so far as is practicable, to be routed clear of high fire risk areas (e.g. galleys, machinery spaces), except for supplying equipment in those spaces.

6.3 Radius of bend

6.3.1 The internal radius of bend for the installation of cables is to be chosen according to the type of cable as recommended by the manufacturer.

6.4 Cable support and protection

6.4.1 Conductors that are not sheathed are not to be accessible and are to be supported throughout their length on cable trays, in cable conduits, ducting pipes or trunking, or by individual supports at maximum intervals of 300 mm. Each conductor longer than 300 mm installed separately is to have a cross-section of at least 1 mm^2.

Note 1: Use of not sheathed conductors is to be limited to yachts whose length is less than 24 metres or for relatively small circuits.

6.4.2 Cables exposed to risk of mechanical damage are to be protected by metal casing, profiles, pipes or other equivalent means, unless the cable covering (e.g. sheath or armour) provides adequate mechanical protection.

6.4.3 Cables are to be installed and supported in such manner as to avoid chafing or other damage.

6.4.4 Cables are to be supported throughout their length in conduits, cable trunking or trays, or by individual supports at maximum intervals of 450 mm.

6.4.5 The supports (tray plates, separate support brackets or hanger ladders) and the corresponding accessories are to be of robust construction and of corrosion-resistant material or suitably treated before erection to resist corrosion.

When cables are installed directly on aluminium structures, fixing devices of aluminium or suitably treated steel are to be used.

6.4.6 With the exception of cables installed in pipes, conduits, trunkings or special casings, cables are to be fixed by means of clips, saddles or straps of suitable material, in order to tighten the cables without their coverings being damaged.

6.4.7 Cable clips or straps made from a material other than metal are to be manufactured of a flame-retardant material.

6.5 Penetration of bulkheads and decks

6.5.1 If cables and conductors have to pass without adequate support through non-watertight bulkheads and generally through holes drilled in sheets of structural steel, these holes are to be fitted with glands or bushings.

Materials used for glands and bushings are to be resistant to corrosion and are not to damage the cable or the yacht’s structure.

6.5.2 Cable penetrations are not to impair the effectiveness of fire protection, watertightness or gas-tight of decks and bulkhead.

6.6 Earthing and continuity of metal coverings of cables

6.6.1 All metal coverings of cables are to be earthed at both ends. Earthing at one end is admitted where it is required for technical or safety reasons.

6.6.2 The electrical continuity of all metal coverings of cables throughout the length of the latter, particularly at joints and tappings, is to be ensured.

6.7 Earthing and continuity of metal pipes, conduits and trunking or casings

6.7.1 Metal casings, conduits and trunking are to be effectively earthed.

6.8 Cable trays/protective casings/conduits made of plastics materials

6.8.1 Cable trays, protective casings or conduits made of plastics materials (thermoplastic or thermosetting plastic material) are to be type tested.

6.8.2 Non-metallic cable trays or protective casings or conduits made are to be flame retardant. We used on open deck, they are to be protected against U.V. light.

6.8.3 The load on the non-metallic cable trays is to be as recommended by the manufacturer.

7 Cabling and wiring

7.1 Cable terminations

7.1.1 Terminations in all conductors are to be so made as to retain the original electrical, mechanical, flame-retarding properties of the cable.

7.1.2 The dimensions and design of cable sockets and clamps are to be such that the maximum current likely to flow through them will not cause the rated operating temperature of the cable insulation to be exceeded.

7.1.3 The means of fixing of conductors and terminals are to be capable of withstanding the thermal and dynamic effects of short-circuits.

7.1.4 Screw-clamp or screwless terminals are to conform to IEC 60947-7-1. Other terminals are to be of the ring or captive-spade type, not dependent on screw or nut tightness alone for retention on the screw or stud. Captive-spade terminals are to be of the self-locking type.

7.1.5 The ends of every conductor are to be securely terminated by a means which contains all the strands of the conductor.

7.1.6 All conductors attached to stud or screw connections are to be fitted with suitable terminals (i.e. no bare wires attached to stud or screw connections).

7.1.7 The number of wires terminated in the same cable socket or clamp is not to exceed the maximum number recommended by the accessory manufacturer.

7.1.8 Exposed shanks of terminals are to be protected against accidental shorting by the use of insulating barriers or sleeves, except those in the protective conductor system.

7.2 D.c. and a.c. segregation

7.2.1 A d.c. circuit is not to be contained in the same wiring system as an a.c. circuit, unless one of the following methods of separation is used:

a) for a multicore cable or cord, the cores of the d.c. circuit are separated from the cores of the a.c. circuit by an earthed metal screen of equivalent current-carrying capacity to that of the largest core in either circuit
b) the cables are insulated for their system voltage and installed in separate compartments of a cable ducting or trunking system
c) the cables are installed on a tray or ladder where physical separation is provided by a partition
d) physically separate conduit, duct, trunking or routing systems are used for d.c. and a.c. systems
e) the d.c. and a.c. conductors are fixed directly to a surface and separated by at least 100 mm.

7.3 Conductor identification

7.3.1 Requirements mentioned in this Article are applicable to yachts of length less than 24 metres.

7.3.2 Each electrical conductor that is part of the electrical system is to have a means to identify its function in the system, except for conductors include in packaged system (e.g engine) and bonding conductors.

7.3.3 All d.c. negative conductors are to be identified by black or yellow insulation. If the yacht is also equipped with an a.c. electrical system using black conductor insulation for phase conductors, yellow insulation is to be used for negative conductors of the d.c. system. Black or yellow insulation are not to be used for d.c. positive conductors

7.3.4 All d.c. positive conductors are to be identified by red insulation.

7.3.5 Means of identification other than colour for d.c. positive conductors is permitted if properly identified on the wiring diagram of the electrical system(s) of the yacht.

7.3.6 Conductor identification for a.c. system is to be in accordance with IEC 60446.

- live conductors: black or brown
- neutral conductors: white or light blue
- protective conductors: green and yellow.

Note 1: A colour stripe or number may be added to the conductor insulation for identification in the system.

Note 2: Yachts with an a.c. and d.c. systems should avoid the use of a brown, white or light blue insulation colour in the d.c. system unless clearly separated from the a.c. conductors and identified.

8 Various appliances

8.1 Lighting fittings

8.1.1 Lighting fittings are to be so arranged as to prevent temperature rises which could damage the cables and wiring.

8.1.2 Lighting fittings are to be so arranged as to prevent surrounding material from becoming excessively hot.

8.1.3 Lighting fittings are to be secured in place such that they cannot be displaced by the motion of the yacht.

8.2 Heating appliances

8.2.1 Space heaters are to be so installed that clothing, bedding and other flammable material cannot come in contact with them in such a manner as to cause risk of fire.

Note 1: To this end, for example, hooks or other devices for hanging garments are not to be fitted above space heaters or, where appropriate, a perforated plate of incombustible material is to be mounted above each heater, slanted to prevent hanging anything on the heater itself.

8.2.2 Space heaters are to be so installed that there is no risk of excessive heating of the bulkheads or decks on which or next to which they are mounted.

8.2.3 Combustible materials in the vicinity of space heaters are to be protected by suitable incombustible and thermal-insulating materials.

8.2.4 The temperature of the external surface of space heaters is not to exceed 60°C.

8.3 Magnetic compass

8.3.1 Cables and equipment are to be placed at a such distance from the compass, or are to be so screened, that the interfering external magnetic field is negligible, causing a compass deviation of no more than 30′ when the circuits are switched on or off under maximum load.

8.4 Socket-outlets

8.4.1 Socket-outlets provided for the galley area are to be located so that the appliance cords may be plugged in without crossing above a galley stove or sink or across a traffic area.

Section 5 Testing

1 General

1.1 Rule application

1.1.1 Before a new installation, or any alteration or addition to an existing installation, is put into service, the electrical installation is to be tested in accordance with [3], [4] and [5] to the satisfaction of the Surveyor in charge.

Such tests are intended to indicate the general condition of the installation at the time of completion; however satisfactory results do not in themselves necessarily ensure that the installation is satisfactory in all respects.

2 Type approved components

2.1

2.1.1 The following components are to be type approved or in accordance with [2.1.2]:

- electrical cables
- switching devices (circuit-breakers, contactors, disconnectors, etc.) and overcurrent protective devices
- computer based systems used for tasks essential to safety
- electric rotating machines, as per required by Ch 2, Sec 3, [3.5]
- sensors, alarm panels, electronic protective devices, automatic and remote control equipment, actuators and safety devices for installations intended for essential services, electronic speed regulators for main or auxiliary engines.

2.1.2 Case by case approval based on submission of adequate documentation and execution of tests may also be granted at the discretion of the Society.

3 Insulation resistance

3.1 Insulation-testing instruments

3.1.1 It is recommended that insulation resistance be measured by self contained instruments such as a direct reading ohmmeter of the generator type, applying a voltage of at least 500 V. The test voltage for system rated less than 230 V is to be limited to twice the rated voltage of the equipment being tested. The insulation resistance is to be recorded together with the ambient temperature and the relative humidity at the time of the test.

Note 1: Any electronic devices present in the installation are to be disconnected prior to the test in order to prevent damage.

Note 2: The measurement is to be taken when the deviation of the measuring device is stabilised.

3.2 Switchboards

3.2.1 Before switchboards or panel boards and distribution boards are put into service, their insulation resistance between each busbar and earth and between each insulated busbar and the busbars connected to the other poles (or phases) is to be measured. The insulation resistance is to be not less than 1 MΩ.

3.2.2 This test is to be performed with all circuit-breakers and switches open, all fuse-links for pilot lamps, earth fault-indicating lamps, voltmeters, etc. removed and voltage coils temporarily disconnected where otherwise damage may result.

3.3 Lighting and power circuits

3.3.1 A test for insulation resistance between all insulated poles (or phases) and earth and, where practicable, between poles (or phases), is to be applied to all permanent wiring. A minimum value of 1 MΩ is to be obtained.

3.4 Generators and motors

3.4.1 The insulation resistance of generators and motors, is to be measured in normal working condition with all parts in place.

3.4.2 The test is to be carried out at operating temperature immediately after running with normal load.

3.4.3 The embedded temperature sensors of the machine, if any, are connected to earth during testing.

3.4.4 The insulation resistance of generator and motor is to be at least 1 MΩ.

3.5 Internal communication circuits

3.5.1 Circuits operating at a voltage of 50 V and above are to have an insulation resistance between conductors and between each conductor and earth of not less than 1 MΩ.

3.5.2 For circuits operating at voltages below 50 V, the insulation resistance is not to be less than 0,33 MΩ.

3.5.3 If necessary, any or all appliances connected to the circuit may be disconnected while the test is being conducted.

4 Earth

4.1 Electrical constructions

4.1.1 Tests are to be carried out, by visual inspection or by means of a tester, to verify that all protective conductors and bonds are connected to the frame of the apparatus and to the hull or earthing plate, and that earth contacts in socket-outlets are connected to earth. The maximum value of the resistance to earth is to be 1,0 Ω.

4.2 Metal-sheathed cables, metal pipes or conduits

4.2.1 Tests are to be performed, by visual inspection or by means of a tester, to verify that the metal coverings of cables and associated metal pipes, conduits, trunking and casings are electrically continuous and effectively earthed.

5 Operational tests

5.1 General

5.1.1 Tests specified in [5.5] and [5.6] are applicable to yachts of 24 metres and over.

5.1.2 Tests specified in [5.7] apply only to yachts of 500 gross tonnage and above.

5.2 Voltage drop

5.2.1 Where it is deemed necessary by the attending Surveyor, the voltage drop on consuming devices is to be measured to verify that the permissible limits specified in Ch 2, Sec 2, [7.8.3] and Ch 2, Sec 2, [7.8.4].

5.3 Switchgear

5.3.1 All switchboard or panel boards and distribution boards are to be loaded as near as practicable to their normal working load in order to ensure that no overheating occurs due to faulty connections or incorrect rating.

When found necessary by the attending Surveyor, switches, circuit-breakers and controls are to be operated on load to test their suitability and to demonstrate that the operation of overcurrent, under-voltage protective devices are electrically and mechanically satisfactory.

Note 1: The workshop test is generally considered sufficient to ensure that such apparatus will perform as required while in operation.

5.4 Consuming devices

5.4.1 Electrical equipment is to be operated under normal service conditions (though not necessarily at full load or simultaneously) to verify that it is suitable and satisfactory for its purpose.

5.4.2 Motors and their starters are to be tested under normal operating conditions to verify that the following are satisfactory:

- power
- operating characteristics
- commutation (if any)
- speed
- direction of rotation
- alignment.

5.4.3 Lighting fittings, heating appliances etc. are to be tested under operating conditions to verify that they are suitable and satisfactory for their purposes.

5.5 Emergency source of electrical power

5.5.1 The satisfactory operation of the emergency source of power, when required, is to be tested. In particular, the automatic starting and the automatic connection to the emergency switchboard, in case of failure of the main source of electrical power, are to be tested.

5.6 Other systems

5.6.1 Each system is to be tested to validate its suitability and to verify its operation to specification. Particular attention should be paid to the testing of communication systems, emergency lighting and fire detection and alarm system.

5.6.2 The remote stops foreseen are to be tested.

5.7 Generating sets and their protective devices

5.7.1 Generating sets are to be run at full rated load to verify that the following are satisfactory:

- electrical characteristics
- commutation (if any)
- lubrication
- ventilation
- noise and vibration level.

5.7.2 Suitable load variations are to be applied to verify the satisfactory operation under steady state and transient conditions (see Ch 2, Sec 3, [3]) of:

- voltage regulators
- speed governors.

5.7.3 Generating sets intended to operate in parallel are to be tested over a range of loading up to full load to verify that the following are satisfactory:

- parallel operation
- sharing of the active load
- sharing of the reactive load (for a.c. generators).

Synchronising devices are also to be tested.

5.7.4 The satisfactory operation of the following protective devices is to be verified:

- overspeed protection
- overcurrent protection (see Note 1)
- any other safety devices.

For sets intended to operate in parallel, the correct operation of the following is also to be verified:

- reverse-power protection for a.c. installations (or reverse-current protection for d.c. installations)
- minimum voltage protection.

Note 1: Simulated tests may be used to carry out this check where appropriate.

Part C
Machinery, Electricity, Automation and Fire Protection

CHAPTER 3
AUTOMATION

Section 1 General Requirements

1 General

1.1 Field of application

1.1.1 The requirements of this Chapter apply to automation systems intended for control, monitoring and safety of main propulsion machinery and essential auxiliary machinery of yachts having power exceeding 220 kW per shaft line.

For other yachts, an adequate control of propulsion machinery and steering is to be provided at the discretion of the Society.

Where the word "yachts" is used in the subsequent sections, it means yachts and charter yachts.

1.1.2 The Flag Administration may request application of National Rules and/or International Regulations. In such a case, it is the Interested Party responsibility to comply with the therein Rules and Regulations.

1.2 Regulations and standards

1.2.1 The regulations and standards applicable are those defined in Ch 2, Sec 1.

1.3 Definitions

1.3.1 Unless otherwise stated, the terms used in this Chapter have the definitions laid down in Ch 2, Sec 1 or in the IEC standards. The following definitions also apply:

- alarm indicator is an indicator which gives a visible and/or audible warning upon the appearance of one or more faults to advise the operator that his attention is required
- alarm system is a system intended to give a signal in the event of abnormal running condition
- automatic control is the control of an operation without direct or indirect human intervention, in response to the occurrence of predetermined conditions
- automation systems are systems including control systems and monitoring systems
- computer based system is a system of one or more computers, associated software, peripherals and interfaces, and the computer network with its protocol
- control station is a group of control and monitoring devices by means of which an operator can control and verify the performance of equipment
- control system is a system by which an intentional action is exerted on an apparatus to attain given purposes
- fail safe is a design property of an item in which the specified failure mode is predominantly in a safe direction with regard to the safety of the yacht, as a primary concern
- local control is control of an operation at a point on or adjacent to the controlled switching device
- instrumentation is a sensor or monitoring element
- manual control is control of an operation acting on final control devices either directly or indirectly with the aid of electrical, hydraulic or mechanical power
- monitoring system is a system designed to observe the correct operation of the equipment by detecting incorrect functioning (measure of variables compared with specified value)
- redundancy is the existence of more than one means for performing a required function
- remote control is the control from a distance of apparatus by means of an electrical or other link.

1.4 General

1.4.1 Computer based systems are to be chosen among the list of type approved products.

They are to be approved on the basis of the applicable requirements of NR467 Rules for Steel Ships, Pt C, Ch 3, Sec 6.

Case by case approval may also be granted at the discretion of the Society, based on submission of adequate documentation and subject to the satisfactory outcome of any required tests.

2 Documentation

2.1 General

2.1.1 Documents listed in Tab 1 are to be submitted.

Table 1 : Documentation to be submitted

No.	I/A **(1)**	Documentation
1	A	Diagram of the supply, monitoring and control systems of propulsion engines
2	A	A general diagram showing the monitoring and/or control positions for the propulsion installations, with an indication of the means of communication between the positions where applicable
3	I	The list of components used in the automation circuits, and references (Manufacturer, type, etc.)
4	I	The diagrams of the supply circuits of automation systems, identifying the power source
5	I	The list of monitored parameters for alarm/monitoring and safety systems
(1) A = to be submitted for approval I = to be submitted for information.		

The list of documents requested is to be intended as guidance for the complete set of information to be submitted, rather than an actual list of titles.

The Society reserves the right to request the submission of additional documents in the case of non-conventional design or if it is deemed necessary for the evaluation of the system, equipment or components.

Plans are to include all the data necessary for their interpretation, verification and approval.

Unless otherwise agreed with the Society, documents for approval are to be sent in triplicate if submitted by the Shipyard and in four copies if submitted by the equipment supplier.

Documents requested for information are to be sent in duplicate.

In any case, the Society reserves the rights to require additional copies, when deemed necessary.

3 Environmental and supply conditions

3.1

3.1.1 Electrical power supply

The automation system is to operate correctly when the power supply is within the range specified in Ch 3, Sec 2.

3.1.2 Environmental conditions

The automation system is to be designed to operate satisfactorily in the environment in which it is located. The environmental conditions are described in Ch 2, Sec 1.

3.1.3 Failure behaviour

The automation system is to have non-critical behaviour in the event of power supply failure, faults or restoration of operating condition following a fault. If a redundant power supply is used, it must be taken from an independent source.

4 Materials and construction

4.1 General

4.1.1 The choice of materials and components construction is to be made according to the environmental, shock and operating conditions in order to maintain the required function of the equipment.

4.1.2 The design location and installation of the automation system is to take into account the environmental, shock and operating conditions in order to maintain the required function of the equipment.

Section 2 Design Requirements

1 General requirements

1.1 General

1.1.1 All control systems are to be independent or designed such that failure of one system does not degrade the performance of another system.

1.1.2 Controlled

Controlled systems are to have manual operation.

Failure of any part of such systems shall not prevent the use of manual override

1.1.3 For diesel engines of 110 kW and over, an appropriate segregation is to be maintained between control, monitoring/alarm and safety functions to limit the effect of single failures.

1.1.4 Unless accepted by the Society, control and alarm systems are to be based on the fail-to-safe principle.

1.1.5 Control and alarm systems are to have self-check facilities. In the event of failure, an alarm is to be activated.

1.1.6 In the case of failure, control systems are to remain in their last position they had before the failure or to fail in a safe condition.

2 Control of machinery

2.1 General requirements

2.1.1 Main and auxiliary machinery essential for the propulsion, control and safety of the yacht is to be provided with effective means for its operation and control.

2.1.2 The control system shall be such that the services needed for the operation of the main propulsion machinery and its auxiliary are ensured through the necessary automatic arrangements.

2.1.3 A system of alarm displays and controls which readily allows identification of faults in the machinery and satisfactory supervision of related equipment is to be provided at the places where the continuous supervision of the machinery installations is maintained.

For detailed instrumentation for each equipment, refer to Part C, Chapter 1 and Part C, Chapter 2.

2.1.4 Yachts may be assigned with additional class notations for unattended machinery spaces as indicated in NR467 Rules for Steel Ships, Pt A, Ch 1, Sec 2, [6.4].

2.2 Control of propulsion machinery

2.2.1 Under all sailing conditions, including manoeuvring, the speed, direction of thrust and, if applicable, the pitch propeller are to be fully controllable from navigation bridge.

2.2.2 The remote control is to include an automatic device such that the number of operations to be carried out is reduced and their nature is simplified and such that control is possible in both ahead and astern directions. Where necessary, means for preventing overload and running in critical speed ranges of the propulsion machinery is to be provided.

2.2.3 The control is to be performed by a single control device for each independent propeller. Where multiple propellers are designed to operate simultaneously, they may be controlled by one control device.

2.2.4 The main propulsion machinery is to be provided with an emergency stopping device on the navigation bridge which is to be independent of the navigation bridge control system.

In the event that there is no reaction to an order to stop, provision is to be made for an alternative emergency stop. This emergency stopping device may consist of a simple and clearly marked control device, for example a push-button. This fitting is to be capable of suppressing the propeller thrust, whatever the cause of failure may be.

2.2.5 Remote control of the propulsion machinery is to be possible only from one location at a time; at such locations interconnected control positions are permitted. At each location, with the exception of fully mechanical remote control systems, there is to be an indicator showing which location is in control of the propulsion machinery. The transfer of control from the navigating bridge and machinery spaces is to be possible only in the propulsion machinery space or in the machinery control room where provided. This system is to include means to prevent the propelling thrust from altering significantly when transferring control from one location to another.

2.2.6 Direct control of the propulsion machinery is to be provided locally. The local direct control is to be independent from the remote control circuits, and takes over any remote control when in use.

It is also to be possible to control the auxiliary machinery, essential for the propulsion and safety of the yacht, at or near the machinery concerned.

2.2.7 The design of the remote control system is to be such that in case of its failure an alarm will be given. Unless impracticable, the preset speed and direction of thrust of the propeller shall be maintained until local control is in operation.

2.2.8 Indicators are to be fitted on the navigation bridge and at the manoeuvring platform, for:

a) propeller speed and direction of rotation in the case of fixed pitch propellers, and

b) propeller speed and pitch position in the case of controllable pitch propellers.

2.2.9 Supply failure in propulsion plant remote control is to activate an alarm at the control position. This applies in particular in the case of loss of electric, pneumatic or hydraulic supply to the system.

2.2.10 As a general rule, the navigation bridge panels are not to be overloaded by alarms and indications which are not required.

3 Power supply of automation systems

3.1

3.1.1 The requirements specified in this Article apply to yachts of 24 metres and over.

3.1.2 Automation systems are to be arranged with an automatic change-over to a continuously available standby power supply in case of loss of normal power source. The change-over to the stand-by power supply is to be achieved without a break for alarm system which could be adversely affected by an interruption in power supply.

3.1.3 The capacity of the standby power supply required in [3.1.2] is to be sufficient to allow the normal operation of the alarm system for at least half an hour.

3.1.4 Failure of any power supply to an alarm system is to generate an audible and visual alarm.

4 Alarm system

4.1 General requirements

4.1.1 Alarms are to be visual and audible and are to be clearly distinguishable, in the ambient noise and lighting in the normal position of the personnel, from any other signals.

4.1.2 Sufficient information is to be provided for proper handling of alarms.

4.2 Alarm functions

4.2.1 Alarm activation

Alarms are to be activated when abnormal conditions appear in the machinery, which need the intervention of personnel.

An existing alarm is not to prevent the indication of any further fault.

4.2.2 Acknowledgement of alarm

The acknowledgment of an alarm consists in manually silencing the audible signal and additional visual signals while leaving the visual signal on the active control station. Acknowledged alarms are to be clearly distinguishable from unacknowledged alarms. Acknowledgement should not prevent the audible signal to operate for new alarm.

Alarms are to be maintained until they are accepted and visual indications of individual alarms have to remain until the fault has been corrected, when the alarm system has to automatically reset to the normal operating condition.

Acknowledgement of alarms is only to be possible at the active control station.

Alarms, including the detection of transient faults, are to be maintained until acknowledgement of the visual indication.

Acknowledgement of visual signals is to be separate for each signal or common to a limited group of signals. Acknowledgement is only to be possible when the user has visual information on the alarm condition for the signal or all signals in a group.

4.2.3 Locking of alarms

Manual locking of separate alarms may be accepted when this is clearly indicated.

Locking of alarm and safety functions in certain operating modes (e.g. during start-up or trimming) is to be automatically disabled in other modes.

4.2.4 Time delay of alarms

It is to be possible to delay alarm activation in order to avoid false alarms due to normal transient conditions (e.g. during start-up or trimming).

5 Safety system

5.1 Design

5.1.1 System failures

A safety system is to be designed so as to limit the consequence of failures. It is to be constructed on the fail-to-safety principle.

5.2 Function

5.2.1 Safety activation

The safety system is to be activated automatically in the event of identified conditions which could lead to damage of associated machinery or systems, such that:

- normal operating conditions are restored (e.g. by the starting of the standby unit), or
- the operation of the machinery is temporarily adjusted to the prevailing abnormal conditions (e.g. by reducing the output of the associated machinery), or
- the machinery is protected, as far as possible, from critical conditions by shutting off the fuel or power supply, thereby stopping the machinery (shutdown), or appropriate shutdown.

5.2.2 Safety indication

When the safety system has been activated, it is to be possible to trace the cause of the safety action. This is to be accomplished by means of a central or local indication.

When a safety system is made inoperative by a manual override, this is to be clearly indicated at corresponding control stations.

Automatic safety actions are to activate an alarm at predefined control stations.

5.3 Shutdown

5.3.1 For shutdown systems of machinery, the following requirements are to be applied:

- when the system has stopped a machine, the latter is not to be restarted automatically before a manual reset of the safety system has been carried out
- the shutdown of the propulsion system is to be limited to those cases which could lead to serious damage, complete breakdown or explosion.

Part C
Machinery, Electricity, Automation and Fire Protection

CHAPTER 4
FIRE PROTECTION, DETECTION AND EXTINCTION

Section 1 General Requirements and Application

1 Application

1.1 General

1.1.1 This Chapter applies to yachts and charter yachts. Where the word "yachts" is used in the subsequent sections, it means yachts and charter yachts.

1.1.2 Charter yachts intended to carry more than 36 passengers are not covered by this Chapter and are to comply with applicable rules for ships granted with service notation **passenger ship**. Requirements specified in NR467 Rules for Steel Ships, Part C, Chapter 4 apply.

1.1.3 Charter yachts intended to carry more than 12 passengers may be considered under this Chapter. In this case, requirements of this Chapter applicable to charter yachts of 500 GT and over apply, in addition to the specific requirements given in Article [2]. Attention is to be drawn on the possible additional requirements of the Flag Administration.

1.1.4 In the present Chapter, the length reference to 24 m applies to L_{LL} as defined in Pt A, Ch 1, Sec 1, [3.2.2].

1.2 National regulations

1.2.1 When the Administration of the State whose flag the yacht is entitled to fly has issued specific rules covering fire protection, the Society may accept such rules for classification purposes in lieu of those given in this Chapter.

In this case, it is the responsibility of the Interested Party to specify to the Society the condition of operation of the Yacht and the applicable specific Flag Rules.

In such cases, a special notation regarding the above is entered on the Certificate of Classification of the yacht.

1.3 Applicable rules depending on ship type

1.3.1 The applicable requirements in the sections of Part C, Chapter 4, depending on the ship type, are summarized in Tab 1.

When reference is made to the Rules for Steel Ships, the latest version of NR467 Rules for Steel Ships is applicable.

Table 1 : Applicable rules in the present Chapter depending on the ship type

Section	Yachts of less than 24 m in length	Yachts of 24 m in length and over and of less than 500 GT	Yachts of 500 GT and over
Section 1	[3], as applicable	[3], as applicable	[3], as applicable
Section 2	X	X	X
Section 3	X, if any	X	X
Section 4	not applicable	X	not applicable
Section 5	X	X	not applicable
Section 6	X	X	not applicable
Section 7	not applicable	not applicable	X
Section 8	not applicable	not applicable	X
Section 9	not applicable	not applicable	X
Section 10	X	X	X
Section 11	X, if any	X, if any	X, if any
Section 12	X, if any	X, if any	X, if any
Section 13	X	X	X

Note 1:
X : The majority of the requirements of this Section are applicable, except those expressly specified to be applicable to other types of yachts.
X, if any : Applicable only if the concerned equipment or space is installed on the yacht.

1.4 Fuel for Auxiliary Vehicles

1.4.1 In case filling, storage and refuelling arrangements are installed on board for oil fuels having a flashpoint below 60°C and dedicated to auxiliary vehicles used during normal ship operation such as zodiac, jet ski or helicopter, the applicable requirements of NR467 Rules for Steel Ships, Pt C, Ch 4, Sec 11 apply.

2 Charter yachts carrying more than 12 passengers

2.1 Applicable rules

2.1.1 General

For charter yachts carrying more than 12 passengers referred to in [1.1.3], requirements of this Chapter applicable to charter yachts of 500 GT and over apply, as well as the additional specific requirements given in [2.1.2] to [2.1.5].

2.1.2 Public address system

A public address system or other effective means of communication complying with the requirements of Pt C, Ch 2, Sec 3, [3.14] of the Rules for Steel Ships is to be available throughout the accommodation and service spaces and control stations and open decks.

2.1.3 Fire doors indication

Requirements of Ch 4, Sec 7, [4.1.1], item d) are applicable, even if the charter yacht has less than two main vertical zones containing accommodation spaces.

2.1.4 Marking of escape routes

In addition to the emergency lighting required in Ch 2, Sec 2, the means of escape, including stairways and exits, are to be marked by lighting or photoluminescent strip indicators placed not more than 300 mm above the deck at all points of the escape route, including angles and intersections. The marking must enable passengers to identify the routes of escape and readily identify the escape exits. If electric illumination is used, it is to comply with NR467 Rules for Steel Ships, Pt D, Ch 11, Sec 5 and it is to be supplied by the emergency source of power and it is to be so arranged that the failure of any single light or cut in a lighting strip will not result in the marking being ineffective. Additionally, escape route signs and fire equipment location markings are to be of photoluminescent material or marked by lighting.

2.1.5 Sources of power supply for automatic sprinkler systems

Requirements of Ch 4, Sec 13, [5.1.2] are replaced by the following requirement:

There are not to be less than two sources of power supply for the sea water pump and automatic alarm and detection system. Where the sources of power for the pump are electrical, these are to be a main generator and an emergency source of power. One supply for the pump is to be taken from the main switchboard, and one from the emergency switchboard by separate feeders reserved solely for that purpose. The feeders are to be so arranged as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk except in so far as it is necessary to reach the appropriate switchboards, and are to be run to an automatic change-over switch situated near the sprinkler pump. This switch has to permit the supply of power from the main switchboard so long as a supply is available therefrom, and be so designed that upon failure of that supply it will automatically change over to the supply from the emergency switchboard. The switches on the main switchboard and the emergency switchboard are to be clearly labelled and normally kept closed. No other switch is to be permitted in the feeders concerned. One of the sources of power supply for the alarm and detection system is to be an emergency source. Where one of the sources of power for the pump is an internal combustion engine it is, in addition to complying with the provisions of Ch 4, Sec 13, [5.1.4], item c), to be so situated that a fire in any protected space will not affect the air supply to the machinery.

3 Other yachts

3.1 Applicable rules

3.1.1 Requirements of the present Article [3] and of Ch 4, Sec 2 to Ch 4, Sec 13 are applicable (see Tab 1).

3.2 Documentation to be submitted

3.2.1 The interested party is to submit to the Society the documents listed in:

- Tab 2 for yachts of less than 24 m in length
- Tab 3 for yachts of 24 m in length and over.

Table 2 : Documentation to be submitted for yachts of less than 24 m in length

No.	A/I **(1)**	Document **(2)**
1	A	Means of escape and, where required, the relevant dimensioning. Escape route signage
2	A	Arrangement of fixed fire-extinguishing systems, if any **(2)**
3	A	Arrangement of sprinkler or sprinkler equivalent systems including the capacity and head of the pumps, if any **(2)**
4	A	Fire control plan showing the position of all fixed or portable extinguishing appliances.
5	A	Electrical diagram of the fixed gas fire-extinguishing system, if any
6	A	Electrical diagram of the sprinkler systems, if any
7	A	Drawings in relation with the protection of vehicle spaces, if any
8	I	General arrangement plan showing the purpose of the various spaces of the yacht

(1) A : To be submitted for approval
I : To be submitted for information.

(2) Plans are to be schematic and functional and to contain all information necessary for their correct interpretation and verification such as:
- service pressures
- capacity and head of pumps and compressors, if any
- materials and dimensions of piping and associated fittings
- volumes of protected spaces, for gas and foam fire-extinguishing systems
- surface areas of protected zones for automatic sprinkler and pressure water-spraying, low expansion foam and powder fire-extinguishing systems
- capacity, in volume and/or in mass, of vessels or bottles containing the extinguishing media or propelling gases, for gas, automatic sprinkler, foam and powder fire-extinguishing systems
- type, number and location of nozzles of extinguishing media for gas, automatic sprinkler, pressure water-spraying, foam and powder fire-extinguishing systems.

All or part of the information may be provided, instead of on the above plans, in suitable operation manuals or in specifications of the systems.

3.3 Type approved products

3.3.1 Yachts of less than 24 m in length

The following materials, equipment, systems or products in general used for fire protection are to be type approved by the Society, except for special cases for which the acceptance may be given for individual yachts on the basis of suitable documentation or ad hoc tests:

a) fixed powder fire-extinguishing systems, including the powder

b) equivalent fixed gas fire extinguishing systems

c) equivalent water-mist fire extinguishing systems

d) sprinkler heads for automatic sprinkler systems.

3.3.2 Yachts of 24 m in length and over and of less than 500 GT

The following materials, equipment, systems or products in general used for fire protection are to be type approved by the Society, except for special cases for which the acceptance may be given for individual yachts on the basis of suitable documentation or ad hoc tests:

a) fire-resisting and fire-retarding divisions (bulkheads or decks) and associated doors

b) materials with low flame spread characteristic when they are required to have such characteristic

c) non-combustible materials

d) sprinkler heads for automatic sprinkler systems

e) nozzles for fixed pressure water-spraying fire-extinguishing systems for machinery spaces, boiler rooms and vehicle spaces

f) sensing heads for automatic fire alarm and fire detection systems

g) fixed fire detection and fire alarm systems

h) fire dampers

i) equivalent water-mist fire extinguishing systems

j) equivalent fixed gas fire extinguishing systems

k) equivalent water-mist automatic sprinkler systems.

Table 3 : Documentation to be submitted for yachts of 24 m in length and over

No.	A/I **(1)**	Document **(2)**
1	A	Structural fire protection, showing the method of construction and the purpose of the various spaces of the yacht, the fire rating of bulkheads and decks, means of closings of openings in A and B class divisions, draught stops (if required)
2	A	Natural and mechanical ventilation systems showing the penetrations on A class divisions, location of dampers, means of closing, arrangements of air conditioning rooms
3	A	Means of escape. Escape route signage
4	A	Automatic fire detection system (including manually operated call points, if required)
5	A	Fire pumps and fire main including pumps head and capacity, hydrant and hose locations
6	A	Arrangement of fixed fire-extinguishing systems, if any **(2)**
7	A	Arrangement of sprinkler or sprinkler equivalent systems including the capacity and head of the pumps, if any **(2)**
8	A	Fire control plan
9	A	Electrical diagram of the fixed gas fire-extinguishing systems, if any
10	A	Electrical diagram of the sprinkler systems, if any
11	A	Drawings in relation with the protection of vehicle spaces, if any
12	A	Electrical diagram of power control and position indication circuits for fire doors (only for yachts of 500 GT and over, if required)
13	I	General arrangement plan

(1) A : To be submitted for approval
I : To be submitted for information.

(2) Plans are to be schematic and functional and to contain all information necessary for their correct interpretation and verification such as:
- service pressures
- capacity and head of pumps and compressors, if any
- materials and dimensions of piping and associated fittings
- volumes of protected spaces, for gas and foam fire-extinguishing systems
- surface areas of protected zones for automatic sprinkler and pressure water-spraying, low expansion foam and powder fire-extinguishing systems
- capacity, in volume and/or in mass, of vessels or bottles containing the extinguishing media or propelling gases, for gas, automatic sprinkler, foam and powder fire-extinguishing systems
- type, number and location of nozzles of extinguishing media for gas, automatic sprinkler, pressure water-spraying, foam and powder fire-extinguishing systems.

All or part of the information may be provided, instead of on the above plans, in suitable operation manuals or in specifications of the systems.

3.3.3 Yachts of 500 GT and over

The following materials, equipment, systems or products in general used for fire protection are to be type approved by the Society, except for special cases for which the acceptance may be given for individual yachts on the basis of suitable documentation or ad hoc tests:

a) fire-resisting and fire-retarding divisions (bulkheads or decks) and associated doors

b) materials for pipes penetrating A or B class divisions (where they are not of steel or other equivalent material)

c) bulkhead or deck penetrations for electrical cables passing through A or B class divisions

d) materials with low flame spread characteristic when they are required to have such characteristic

e) non-combustible materials

f) non-readily igniting materials for primary deck coverings

g) flexible pipes and expansion bellows of non-conventional material for any type of fluid

h) sprinkler heads for automatic sprinkler systems

i) nozzles for fixed pressure water-spraying fire-extinguishing systems for machinery spaces, boiler rooms and vehicle spaces

j) sensing heads for automatic fire alarm and fire detection systems

k) fixed fire detection and fire alarm systems

l) fire dampers

m) equivalent water-mist fire extinguishing systems

n) equivalent fixed gas fire extinguishing systems

o) equivalent water-mist automatic sprinkler systems.

3.3.4 Regarding the granting of type approval, the requirements of Part A apply.

The Society may request type approval for other materials, equipment, systems or products required by the applicable provisions for yachts or installations of special types.

3.4 Definitions

3.4.1 Accommodation spaces

Accommodation spaces are those spaces used for halls, dining rooms, lounges and similar permanently enclosed spaces, corridors, stairs, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances (as defined in [3.4.19], item a)) and similar spaces.

3.4.2 A class divisions

"A" class divisions are those divisions formed by bulkheads and decks which comply with the following criteria:

a) they are constructed of steel or other equivalent material

b) they are suitably stiffened

c) they are insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180°C above the original temperature, within the time listed below:

- class "A-60" .... 60 minutes
- class "A-30" .... 30 minutes
- class "A-15" .... 15 minutes
- class "A-0" .... 0 minute

d) they are so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test; and

e) the Society required a test of a prototype bulkhead or deck in accordance with the Fire Test Procedures Code (see [3.4.10]) to ensure that it meets the above requirements for integrity and temperature rise.

f) equivalent arrangements may be accepted, if they comply with Ch 4, Sec 2, [3.2].

The products indicated in Tab 4 may be installed without testing or approval.

3.4.3 Atrium

Atriums are public spaces within a single main vertical zone spanning three or more open decks

3.4.4 B class divisions

"B" class divisions are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following criteria:

a) they are constructed of approved non-combustible materials and all materials used in the construction and erection of "B" class divisions are non-combustible, with the exception that combustible veneers may be permitted provided they meet other appropriate requirements of this Chapter

b) they have an insulation value such that the average temperature of the unexposed side will not rise more than 140°C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225°C above the original temperature, within the time listed below:

- class "B-15" .... 15 minutes
- class "B-0" .... 0 minute

c) they are so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test, and

d) the Society required a test of a prototype division in accordance with the Fire Test Procedures Code (see [3.4.10]) to ensure that it meets the above requirements for integrity and temperature rise

e) Equivalent arrangements may be accepted, if they comply with Ch 4, Sec 2, [3.2].

In order to be defined as B class, a metal division is to have plating thickness not less than 2 mm when constructed of steel.

Table 4 : Products installed without testing or approval

Classification	Product description
Class A-0 bulkhead	A steel bulkhead with dimensions not less than the minimum dimensions given below: • thickness of plating: 4 mm • stiffeners 60 x 60 x 5 mm spaced 600 mm apart or structural equivalent
Class A-0 deck	A steel deck with dimensions not less than the minimum dimensions given below: • thickness of plating: 4 mm • stiffeners 95 x 65 x 7 mm spaced 600 mm apart or structural equivalent

3.4.5 Cabin balconies

Cabin balcony is an open deck which is provided for the exclusive use of the occupants of a single cabin and has direct access from such a cabin.

3.4.6 C class divisions

"C" class divisions are divisions constructed of approved non-combustible materials. They need meet neither requirements relative to the passage of smoke and flame nor limitations relative to the temperature rise. Combustible veneers are permitted provided they have low-flame spread characteristics.

3.4.7 Continuous B class ceilings or linings

Continuous "B" class ceilings or linings are those "B" class ceilings or linings which terminate at an "A" or "B" class division.

3.4.8 Control stations

Control stations are those spaces in which the yacht's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized.

3.4.9 Escape ways

On yachts of 24 m in length and over, escape ways are those spaces used by the persons on board to go to the embarkation areas:

- from the door of their cabin, or
- from the door of any collective space, such as mess room, or
- from the door of any occupied service space.

3.4.10 Fire Test Procedures Code

Fire Test Procedures Code means the “International Code for Application of Fire Test Procedures”, as adopted by the Maritime Safety Committee of the IMO by Resolution MSC.307(88), as may be amended by the IMO.

3.4.11 Furniture of restricted fire risk

Furniture of restricted fire risk is furniture complying with the following:

a) case furniture such as desks, wardrobes, dressing tables, bureaux, or dressers are constructed entirely of approved non-combustible materials, except that a combustible veneer not exceeding 2 mm may be used on the working surface of such articles

b) free-standing furniture such as chairs, sofas, or tables are constructed with frames of non-combustible materials

c) draperies, curtains and other suspended textile materials have qualities of resistance to the propagation of flame not inferior to those of wool having a mass of 0,8 kg/m^2, this being determined in accordance with the Fire Test Procedures Code (see [3.4.10])

d) upholstered furniture has qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the Fire Test Procedures Code (see [3.4.10])

e) bedding components have qualities of resistance to the ignition and propagation of flame, this being determined in accordance with the Fire Test Procedures Code (see [3.4.10]).

3.4.12 Galleys

Spaces containing a deep fat fryer, an open flame cooking appliance, any electrically heated cooking plate or hot plate for keeping food warm with a power of more than 5 kW are to be regarded, for the purpose of Ch 4, Sec 4 to Ch 4, Sec 6, as galleys.

3.4.13 Low-flame-spread

a) A low flame-spread means that the surface thus described will adequately restrict the spread of flame, this being determined in accordance with the Fire Test Procedures Code

b) Non-combustible materials are considered as low flame spread. However, due consideration will be given by the Society to the method of application and fixing.

3.4.14 Machinery spaces

Machinery spaces are machinery spaces of category A and other spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

3.4.15 Machinery spaces of category A

Machinery spaces of category A are those spaces and trunks to such spaces which contain either:

a) internal combustion machinery used for main propulsion

b) internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or

c) any oil-fired boiler or oil fuel unit, or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

3.4.16 Main vertical zones

Main vertical zones are those sections into which the hull, superstructure and deckhouses are divided by "A" class divisions, the mean length and width of which on any deck does not in general exceed 40 m.

3.4.17 Non-combustible material

a) Non-combustible material is a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the Fire Test Procedures Code. Any other material is a combustible material

b) In general, products made only of glass, concrete, ceramic products, natural stone, masonry units, common metals and metal alloys are considered as being non-combustible and may be installed without testing and approval.

3.4.18 Oil fuel unit

a) The oil fuel unit is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 0,18 MPa.

b) "Fuel oil unit" includes any equipment used for the preparation and delivery of fuel oil, whether or not heated, to boilers (including inert gas generators) and engines (including gas turbines) at a pressure of more than 0,18 MPa.

3.4.19 Pantries

Pantries (including isolated pantries) containing no cooking appliances may contain:

- toasters, microwave ovens, induction plates and similar appliances, each with a maximum power of 5 kW
- coffee automats, dishwashers and water boilers without any limit of power
- electrically heated cooking plates and hot plates for keeping food warm, each with a maximum power of 2kW and a surface temperature not greater than 150°C.

A dining room containing such appliances is not regarded as a pantry.

3.4.20 Public space

Public spaces are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

3.4.21 Steel or other equivalent material

Steel or other equivalent material means any non-combustible material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (e.g., aluminium alloy with appropriate insulation).

3.4.22 Service spaces

Service spaces are those spaces used for galleys (as defined in [3.4.12]), pantries containing cooking appliances (as defined in [3.4.19] item b)), lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces.

Services spaces of high fire risk are galleys, paint lockers and spaces for the storage of flammable liquids.

3.4.23 Standard fire test

A standard fire test is a test in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time-temperature curve in accordance with the test method specified in the Fire Test Procedures Code (see [3.4.10]).

3.4.24 Vehicle spaces

Spaces containing vehicles or crafts with fuel in their tanks for their own propulsion.

Section 2 Prevention of Fire

1 General

1.1 Application

1.1.1 Article [2]and sub-articles [3.2] and [3.3] are applicable to all yachts.

1.1.2 Yachts of less than 24 m in length

Requirement [3.3.1] is only applicable to yachts of less than 24 m in length.

1.1.3 Yachts of 24 m in length and over and of less than 500 GT

Requirements [3.1.1], [3.3.2] and [3.5.1] are only applicable to yachts of 24 m in length and over and of less than 500 GT.

1.1.4 Yachts of 500 GT and over

Requirements [3.1.2], [3.3.2], [3.4.1], [3.5.2], [3.6.1] and [3.7.1] are only applicable to yachts of 500 GT and over.

2 Probability of ignition

2.1 Machinery spaces

2.1.1 Machinery spaces boundaries

The machinery spaces of category A, as well as their funnels, are to be separated from accommodation spaces and store rooms containing combustible materials and liquids. Their enclosure should not be permeable to oil fuel and oil fuel vapors.

2.1.2 Ventilation

Machinery spaces of category A are to be ventilated to prevent the build-up of explosive gases.

2.2 Galley equipment

2.2.1 Open flame gas appliances

According to ISO 9094 - 1/- 2 [4.3.2.2], for cooking units using fuel which is liquid at atmospheric pressure (see ISO 14895), open-flame burners are to be fitted with a readily accessible drip-pan.

2.2.2 Combustible materials near open-flame cooking appliances

Materials and finishes used in the vicinity of open-flame cooking devices within the ranges defined in Fig 1 are to comply with the following requirements, taking into account the movement of the burner up to an angle of 20° for monohull sailboats and 10° for multihulls and monohull motorboats, where gimballed stoves are fitted:

a) Free-hanging curtains or other fabrics are not to be fitted in Zone I and Zone II

b) Exposed materials installed in Zone I are to be glass, ceramics, aluminium, ferrous metals, or other materials with similar fireproof characteristics

c) Exposed materials installed in Zone II are to be glass, ceramics, metal or other material with similar fireproof characteristics. They are to be thermally insulated from the supporting substrate to prevent combustion of the substrate, if the surface temperature exceeds 80 °C.

Note 1: The thermal insulation may be achieved by an air gap or the use of a suitable material.

2.2.3 Combustible materials near other cooking appliances

The location of any electric cooking plate or any oven is to be such that curtains or other similar materials cannot be scorched or set on fire by heat from the element.

2.3 Other ignition sources

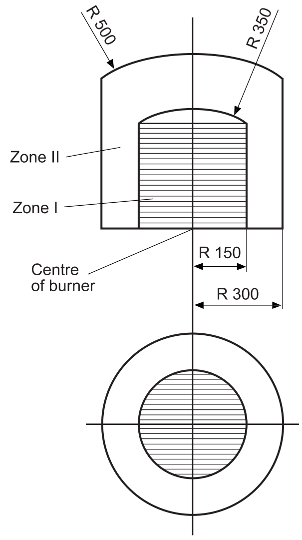
2.3.1 Electric heaters

Electric heaters, if used, are to be fixed in position and so constructed as to reduce fire risks to a minimum. No such heaters are to be fitted with an element so exposed that clothing, curtains, or other similar materials can be scorched or set on fire by heat from the element.

2.3.2 Open flame gas appliances outside galleys

Open flame gas appliances used as heating or lighting appliances are not permitted.

Figure 1 : Areas of special material requirements



Dimensions in mm

Measurement from the center of the burner.

2.3.3 Saunas

Construction and arrangement of saunas is subject to particular requirements as defined below:

- boundaries of the sauna area (comprising dedicated bathrooms and changing rooms, considered as part of the sauna areas) are to comply with Ch 4, Sec 4, [2.2.3], item b) or with Ch 4, Sec 7, [2.1.4], item f), as applicable
- wooden linings, ceilings and benches are permitted inside the sauna area
- the ceiling above the oven is to be lined with a non-combustible plate with an air gap of at least 30 mm. The distance from the hot surface to combustible materials is to be at least 500 mm or the combustible materials are to be protected by similar dispositions as for the ceiling
- the sauna door is to open outwards by pushing
- electrically heated ovens are to be provided with a timer
- all spaces within the sauna area are to be protected by a fire detection and alarm system and an automatic sprinkler system.

2.3.4 Hammam rooms (steam rooms)

Construction and arrangement of hammam rooms is subject to particular requirements as defined below:

- boundaries of the hammam area (comprising dedicated bathrooms and changing rooms, considered as part of the hammam areas) are to comply with Ch 4, Sec 4, [2.2.3], item c) or with Ch 4, Sec 7, [2.1.4], item f), as applicable
- all spaces within the hammam area are to be protected by a fire detection and alarm system.

3 Fire growth potential and control of smoke spread: requirements for materials

3.1 Material of hull, superstructures, structural bulkheads, decks and deckhouses

3.1.1 Yachts of 24 m in length and over and of less than 500 GT

The hull, superstructure, structural bulkheads and decks other than fire divisions, deckhouses and pillars are to be constructed of approved non-combustible materials having adequate structural properties. Alternatively, the use of combustible materials may be permitted if precautions are taken to preserve the hull integrity in case of fire in machinery spaces of category A or other spaces of high fire risk. On yachts constructed in materials other than steel, appropriate fire insulation is also to be fitted on the pillars, the upper deck and lateral exterior boundaries from 300 mm below the water line in the lightweight condition up to the deck forming the upper boundary of the machinery space of category A or other spaces of high fire risk (such as galleys).

3.1.2 Yachts of 500 GT and over

The hull, superstructures, structural bulkheads, decks and deckhouses are to be constructed of steel or equivalent material. For this purpose, an equivalent material to steel means a material that by itself or due to non-combustible insulation provided, has fire resistance properties equivalent to the properties of the corresponding steel division. Insulation need not to be applied on the upper side of decks and the outside of steel yacht. On yachts constructed in materials other than steel, precautions are to be taken to preserve the hull integrity in case of fire.

3.2 Fire divisions

3.2.1 Fire divisions, where required, are to be constructed in accordance with the following requirements.

3.2.2 Fire divisions are to be constructed of steel or any equivalent material, if it can be demonstrated by means of a type test that the material by itself, or due to non-combustible insulation provided, has fire resistance properties equivalent to the properties of the A-class (60 minutes fire integrity) or B-class (30 minutes fire integrity) fire division required by these Rules.

3.2.3 Fire divisions other than steel

Insulation is to be such that the temperature of the structural core does not rise above the point at which the structure would begin to lose its strength at any time during the exposure to the standard fire test (60 minutes for A-class equivalence, 30 minutes for B-class equivalence).

a) Aluminium alloy structures

   The insulation is to be such that the temperature of the structural core does not rise more than 200°C above the ambient temperature at any time during the applicable fire exposure.

b) Composite structures

   The insulation is to be such that the temperature of the laminate does not rise more than the minimum temperature of deflection under load (HDT) of the resin at any time during the applicable fire exposure. The temperature of deflection under load is to be determined in accordance with a recognized international standard (as for example ISO 75-2004).

Note 1: Alternatively, the temperature of deflection under load of the complete composite structure, if available, may be taken as a criterion in lieu of the temperature of deflection under load of the resin.

c) Wood structures

   Wood structures are to be given special consideration from the Society. As a principle, the insulation is to be such that the temperature of the structural core does not rise more than the minimum temperature of deflection under load of the wood at any time during the applicable fire exposure.

For yachts of 500 GT and over, a vertical fire division between two spaces is generally to be insulated on both sides.

For yachts of less than 500 GT, insulation need only be applied on the side of the vertical fire division that is exposed to the greatest fire risk, except if two high fire risk spaces are adjacent (such as, for example, a sauna adjacent to a machinery space of category A).

Special attention is to be given to the fixing of fire door frames in such bulkheads. Measures are to be taken to ensure that the temperature of the fixings when exposed to fire does not exceed the temperature at which the bulkhead itself loses strength.

3.2.4 Equivalent A class fire divisions without testing

A fire-resisting bulkhead may be considered to be equivalent to A class without testing, if its composition is one of the following:

- an uninsulated steel plate minimum 4,0 mm thick complying with Ch 4, Sec 1, Tab 4: equivalent to A-0 class
- a steel plate minimum 4,0 mm thick insulated with minimum 50 mm of non-combustible rock wool (minimal density: 96 kg/m^3; welded pins spacing: maximum 300 mm): equivalent to A-30, A-15 and A-0 class
- an aluminium alloy plate minimum 5,5 mm thick insulated with 80 mm of non-combustible rock wool (minimal density: 96 kg/m^3; welded bi-metallic pins spacing: maximum 300 mm): equivalent to A-30, A-15 and A-0 class
- a composite structure insulated with 120 mm of non-combustible rock wool (minimal density: 96 kg/m^3; pins spacing: maximum 300 mm): equivalent to A-30, A-15 and A-0 class.

3.2.5 Equivalent B class fire divisions without testing

A fire-resisting bulkhead may be considered to be equivalent to B class without testing, if its composition is one of the following:

- an uninsulated steel plate minimum 2,0 mm thick: equivalent to B-0 class
- a steel plate insulated with minimum 30 mm of non-combustible rock wool (minimal density: 96 kg/m^3): equivalent to B-15 and B-0 class
- an aluminium alloy plate with 50 mm of non-combustible rock wool (minimal density: 96 kg/m^3): equivalent to B-15 and B-0 class
- a composite structure insulated with 75 mm of non-combustible rock wool (minimal density: 96 kg/m^3; pins spacing: maximum 300 mm): equivalent to B-15 and B-0 class.

3.3 Insulation materials

3.3.1 Yachts of less than 24 m in length

Materials used for the insulation of the machinery spaces of category A are to be either:

a) self-extinguishing. This property may be determined by means of the oxygen index (OI) method (criteria: OI > 21 at 60°C) in accordance with ISO 4589-3 or by means of another recognized standard, or

b) covered by an intumescent cover material to the satisfaction of the Society.

3.3.2 Yachts of 24 m and over

a) As a principle, insulating materials are to be non-combustible, except in baggage rooms and refrigerated compartments of service spaces. Vapour barriers and adhesives used in conjunction with insulation, as well as insulation of pipe fittings for refrigeration systems and chilled water piping for air conditioning systems, need not be of non-combustible materials, but they are to be kept to the minimum quantity practicable and their exposed surfaces are to have low flame-spread characteristics.

b) However, for yachts of less than 500 GT protected by a fixed fire detection and alarm system in all enclosed spaces except those containing no significant fire risk (toilets, bathrooms, void spaces, etc.), the following applies:

- insulating materials used in machinery spaces of category A are to be of non-combustible materials. The surface of insulation fitted on the internal boundaries of machinery spaces of category A is to be impervious to oil or oil vapors.
- acoustic or thermic insulating materials used in accommodation spaces, service spaces, control stations and auxiliary machinery spaces except in refrigerated compartments are to be at least self-extinguishing. This property may be determined by means of the oxygen index (OI) method (criteria: OI > 21 at 60°C) in accordance with ISO 4589-3 or by means of another recognized standard.

The fixed fire detection and alarm system shall comply with Ch 4, Sec 13, [5].

3.4 Primary deck coverings

3.4.1 Yachts of 500 GT and over

Primary deck coverings, if applied within accommodation and service spaces and control stations are to be of approved material which will not readily ignite, this being determined in accordance with the Fire Test Procedures Code.

3.5 Surface materials and adhesives

3.5.1 Yachts of 24 m in length and over and of less than 500 GT

Exposed surfaces of surface materials and adhesives used in conjunction with fire insulation are to have low-flame spread characteristics.

3.5.2 Yachts of 500 GT and over

a) If a fixed fire detection and alarm system but no automatic sprinkler system is fitted in accordance with Ch 4, Sec 3, [5.2.1], exposed surfaces in corridors and stairways enclosures and of ceilings in accommodation and service spaces (except saunas) and control stations are to be of low-flame spread characteristics and not be capable of producing excessive quantities of smoke and toxic products, in accordance with the Fire Test Procedures Code.

b) If an automatic sprinkler is installed in addition to the fixed fire detection and alarm system in accordance with Ch 4, Sec 3, [5.2.1], item b), exposed surfaces in corridors and stairways enclosures and of ceilings in the galley are to be of low-flame spread characteristics and not be capable of producing excessive quantities of smoke and toxic products, in accordance with the Fire Test Procedures Code.

c) For yachts other than charter yachts carrying more than 12 passengers, if an automatic sprinkler and a fully addressable fire and detection system are installed, exposed surfaces in corridors and stairway enclosures are not required to be of low-flame spread characteristics.

3.6 Ceilings and linings

3.6.1 Yachts of 500 GT and over

As a principle, all linings, grounds, draught stops and ceilings are to be of non-combustible materials except in baggage rooms, saunas or refrigerated compartments of service spaces.

3.7 Furniture in stairway enclosures and cabins corridors

3.7.1 Yachts of 500 GT and over

Furniture in stairway enclosures is to be limited to seating. It is to be fixed, limited to six seats on each deck in each stairway enclosure, be of restricted fire risk determined in accordance with the Fire Test Procedures Code, and is not to restrict the escape route. The Society may permit additional seating in the main reception area within a stairway enclosure if it is fixed, non-combustible and does not restrict the passenger escape route. In addition to the above, lockers of non-combustible material, providing storage for non-hazardous safety equipment required by these regulations, may be permitted.

Furniture should not be permitted in passenger corridors forming escape routes in cabin areas. Furniture may be permitted in crew corridors forming escape routes in cabin areas, providing it is fixed and does not restrict the escape route.

Drinking water dispensers and ice cube machines may be permitted in corridors provided they are fixed and do not restrict the width of the escape routes. This applies as well to decorative flower or plant arrangements, statues or other objects of art such as paintings and tapestries in corridors and stairways.

Section 3 Detection and Alarm

1 General

1.1 Application

1.1.1 The present Section applies to all yachts.

1.1.2 Yachts of less than 24 m in length

Article [3] is applicable to yachts of less than 24 m in length.

1.1.3 Yachts of 24 m in length and over and of less than 500 GT

Articles [2] and [4] and sub-article [5.1] are applicable to yachts of 24 m in length and over and of less than 500 GT.

1.1.4 Yachts of 500 GT and over

Articles [2], [4] and [6] and sub-article [5.2] are applicable to yachts of 500 GT and over.

2 Initial and periodical tests

2.1 General

2.1.1 The function of fixed fire detection and fire alarm systems required by the relevant sections are to be tested under varying conditions of ventilation after installation.

2.1.2 The function of fixed fire detection and fire alarm systems are to be periodically tested to the satisfaction of the Society by means of equipment producing hot air at the appropriate temperature, or smoke or aerosol particles having the appropriate range of density or particle size, or other phenomena associated with incipient fires to which the detector is designed to respond.

3 Protection of the machinery spaces of category A for yachts of less than 24 m in length

3.1 Installation

3.1.1 General

Smoke detection is to be provided in the machinery spaces of category A. It can be a self-contained smoke alarm or a fixed fire detection and alarm system.

3.1.2 Self-contained smoke alarm

If fitted on board, the self-contained smoke alarm has to comply with ISO 12239 or by another recognised standard.

3.1.3 Fixed fire detection and alarm system

If a fixed fire detection and alarm system is fitted on board, it has to comply with applicable requirements of Ch 4, Sec 13, [6], except item a) of Ch 4, Sec 13, [6.1.4].

4 Protection of machinery spaces of category A

4.1 Installation

4.1.1 A fixed fire detection and alarm system complying with Ch 4, Sec 13, [6] is to be installed in machinery spaces of category A.

4.2 Design

4.2.1 The fixed fire detection and fire alarm system required in [4.1.1] are to be so designed and the detectors so positioned as to detect rapidly the onset of fire in any part of those spaces and under any normal conditions of operation of the machinery and variations of ventilation as required by the possible range of ambient temperatures. Except in spaces of restricted height and where their use is specially appropriate, detection systems using only thermal detectors are not to be permitted.

4.2.2 The detection system is to initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire, in sufficient places to ensure that the alarms are heard and observed on the navigation bridge and by a responsible engineer officer. When the navigation bridge is unmanned, the alarm is to sound in a place where a responsible member of the crew is on duty.

5 Protection of accommodation and service spaces

5.1 Yachts of 24 m in length and over and of less than 500 GT

5.1.1 In connection with Ch 4, Sec 2, [3.3.2] b), a fixed fire detection and alarm system complying with Ch 4, Sec 13, [6] is to be installed in all enclosed spaces.

5.1.2 If, the yacht complies with Ch 4, Sec 2, [3.3.2]a), a fixed fire detection and alarm system complying with Ch 4, Sec 13, [6] is to be installed either:

a) in accommodation and service spaces arranged as to provide smoke detection in escape ways within accommodation spaces, if Method 1 or Method 2 is used as referred to in Ch 4, Sec 4, [2.3.1], or

b) in accommodation and service spaces arranged as to provide smoke detection in escape ways and detect the presence of fire in all accommodation and service spaces, if Method 3 is used as referred to in Ch 4, Sec 4, [2.3.1].

Spaces having little or no fire risk such as voids, sanitary spaces, private bathrooms not containing any wardrobe, carbon dioxide rooms and similar spaces need not be fitted with a fixed fire detection and alarm system. Heat detectors in lieu of smoke detectors may be installed in galleys, laundries and refrigerated stores.

5.2 Yachts of 500 GT and over

5.2.1 There is to be installed in accommodation, service spaces and control stations throughout each separate main vertical zone, either:

a) a fixed fire detection and alarm system complying with Ch 4, Sec 13, [6] arranged as to provide smoke detection in corridors, stairways and escape routes within accommodation spaces and detect the presence of fire in all accommodation, service spaces and control stations, or

b) an automatic sprinkler system complying with the relevant requirements of Ch 4, Sec 13, [5] in all accommodation, service spaces and control stations and, in addition, a fixed fire detection and alarm system complying with Ch 4, Sec 13, [6] arranged as to provide smoke detection in corridors, stairways and escape routes within accommodation spaces.

Spaces having little or no fire risk such as voids, sanitary spaces, private bathrooms not containing any wardrobe, carbon dioxide rooms and similar spaces need not be fitted with a fixed fire detection and alarm system. Heat detectors in lieu of smoke detectors may be installed in galleys, laundries and refrigerated stores.

6 Manually operated call points

6.1 Yachts of 500 GT and over

6.1.1 Manually operated call points complying with the requirements of Ch 4, Sec 13, [6] are to be installed throughout the accommodation spaces, service spaces and control stations. One manually operated call point is to be located at each exit. Manually operated call points are to be readily accessible in the corridors of each deck such that no part of the corridor is more than 20 m from a manually operated call point.

Section 4 Containment of Fire for Yachts of less than 500 GT

1 General

1.1 Application

1.1.1 The present Section applies to yachts of 24 m in length and over and of less than 500 GT.

2 Thermal and structural boundaries

2.1 General

2.1.1 Principle

Yachts are to be subdivided into spaces by thermal and structural divisions having regard to the fire risk of the space.

2.1.2 Materials

For materials which can be used in fire divisions, refer to Ch 4, Sec 2, [3]. Furthermore, linings, ceilings and A and B class divisions facings may be made of combustible materials.

2.2 A class divisions

2.2.1 Machinery spaces of category A boundaries

Machinery spaces of category A are to be separated from other adjacent spaces by minimum A-30 class structural gastight bulkheads and decks.

Note 1: If the hull is made of a material other than steel, refer to Ch 4, Sec 2, [3.1].

Note 2: Independent fuel oil tanks made of materials other than steel are subject to specific fire insulation requirements, as referred to in Ch 1, Sec 8, [2.3.2], item b).

For yachts having the navigation notation **sheltered area**, **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, and for yachts under 300 UMS not engaged in trade, machinery spaces of category A are to be separated from other adjacent spaces by minimum B-15 class bulkheads and decks.

2.2.2 Vehicle spaces

Vehicle spaces are to be separated from adjacent accommodation spaces by bulkheads and decks with the same fire integrity as the machinery spaces of category A boundaries.

2.2.3 Saunas and hammam rooms boundaries

a) Saunas and hammam rooms, are to comply with Ch 4, Sec 2, [2.3.3] or Ch 4, Sec 2, [2.3.4], as applicable.

b) Boundaries of the sauna area (comprising dedicated bathrooms and changing rooms, considered as part of the sauna area) are to be of the same fire integrity as the machinery spaces of category A boundaries.

c) Construction of hammam rooms is subject to particular requirements as defined hereafter:

- Boundaries of the hammam area (comprising dedicated bathrooms and changing rooms, considered as part of the hammam area) are to be constructed to an A-0 class standard, if the steam generator is more than 5 kW and is contained within the hammam area. If the steam generator is more than 5 kW but is not contained within the hammam area, the boundaries are to be constructed of B-0 class divisions, and the steam generator is to be protected by A-0 class divisions.

Note 1: For yachts of less than 500 GT having navigation notation **sheltered area**, **coastal area** or **navigation limited to 60 nautical miles** as defined in Pt A, Ch 1, Sec 2, and for yachts under 300 UMS not engaged in trade, A-0 class standard may be replaced by B-0 class standard.

Note 2: If the steam generator is not contained within the hammam area and if the hammam area is located in a private bathroom containing a limited quantity of combustible materials (i.e. without wardrobe for example), hammam area boundaries are not required to be constructed of B-0 class divisions. However, requirements for steam generator enclosures remain applicable.

- If a sauna is comprised within the hammam area, the requirements of item b) for saunas are applicable.

2.2.4 Prevention of heat transmission

Where the structure or 'A' Class divisions are required to be insulated, it is to be ensured that the heat from a fire is not transmitted through the intersections and terminal points of the divisions or penetrations to uninsulated boundaries. Where the installed insulation does not achieve this, arrangements are to be made to prevent this heat transmission by insulating the horizontal and vertical boundaries or penetrations for a distance of 450 mm.

Table 1 : Minimal fire integrity of bulkheads within accommodation and service spaces

Bulkhead class required between space / adjacent space	Methods of construction		
	Method 1	Method 2	Method 3
Service spaces of high fire risk / accommodation or service space or control stations	B-15	_	B-0
Escape ways / accommodation or service space other than escape ways	B-15	_	_
Note 1: Types of spaces and B class divisions are defined in Ch 4, Sec 1, [3.4]. **Note 2:** Where two or more different fire integrities are possible according to this Table, the most stringent boundary requirement is to be applied. **Note 3:** Service spaces of high fire risk are defined in Ch 4, Sec 1, [3.4.22]			

2.3 Method of construction within accommodation and service spaces

2.3.1 Different methods of construction

Three methods of construction are possible:

a) Method 1: A fixed fire detection and alarm system complying with Ch 4, Sec 13, [6] is installed and arranged as to provide smoke detection in escape ways

b) Method 2: A fixed fire detection and alarm system complying with Ch 4, Sec 13, [6] is installed and arranged as to provide smoke detection in escape ways and, in addition, an automatic sprinkler, fire detection and alarm system complying with Ch 4, Sec 13, [5] is installed and arranged as to protect all accommodation and service spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc.

c) Method 3: A fixed fire detection and alarm system complying with Ch 4, Sec 13, [6] is installed and arranged as to detect the presence of fire in all accommodation and service spaces and to provide smoke detection in escape ways.

2.3.2 Bulkhead fire integrity

Fire integrity of bulkheads is to be in accordance with Tab 1.

Bulkheads required to be B class divisions are to extend from deck to deck or to other B class boundaries.

2.3.3 Deck fire integrity

Decks are to be generally so constructed as to provide a level of smoke and fire tightness acceptable to the Society.

If a service space of high fire risk (see **(1)** in Tab 1) is located below an accommodation or service space, deck above the service space of high fire risk should be at least of the same fire integrity as the equivalent bulkhead taken from Tab 1.

For machinery spaces of category A boundaries, refer to [2.2.1].

3 Protection of openings and penetrations in fire-resisting divisions

3.1 General

3.1.1 Openings in 'A' and 'B' Class divisions mentioned in [2.1] are to be restricted to the minimum necessary and are to be fitted with permanently attached means of closing that are to be at least as effective for resisting fires as the divisions in which they are fitted.

3.2 Doors

3.2.1 Doors leading to machinery spaces of category A, to the wheelhouse and to stairways are to be self-closing.

3.3 Penetrations

3.3.1 Where 'A' Class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., arrangements are to be made to ensure that the fire resistance is not impaired.

3.3.2 Where 'B' Class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements are to be made to ensure that the fire resistance is not impaired.

4 Protection of openings in machinery space boundaries

4.1 Windows and skylights

4.1.1 Windows and skylights to machinery spaces are to be as follows:

a) where skylights can be opened, they are to be capable of being closed from outside the space. Skylights containing glass panels are to be fitted with external shutters of steel or other equivalent material permanently attached

b) glass or similar materials are not to be fitted in machinery space boundaries. This does not preclude the use of wire-reinforced glass for skylights and glass control rooms within the machinery spaces

c) in skylights referred to in item a), wire-reinforced glass is to be used.

5 Ventilation

5.1 Ventilation fans stops

5.1.1 It is to be possible to stop ventilation fans and to close main inlets and outlets to ventilation systems from a position outside the spaces served, except in spaces provided with heating stoves.

5.2 Arrangement of ducts

5.2.1 Ventilation ducts for machinery spaces of category A, galleys or vehicle spaces are not in general to pass through accommodation spaces, service spaces or control stations unless the ducts are constructed of steel and arranged to preserve the integrity of the division, as required in [2.2.1].

5.2.2 Ventilation ducts of accommodation spaces, service spaces or control stations are not, in general, to pass through machinery spaces of category A unless the ducts are constructed of steel and arranged to preserve the integrity of the division, as required in [2.2.1].

5.2.3 Store-rooms containing substantial quantities of flammable products are to be provided with ventilation arrangements which are separate from other ventilation systems. Ventilation is to be arranged at high and low levels and the inlets and outlets of ventilators are to be positioned in safe areas and fitted with spark arresters.

5.2.4 Ventilation systems serving machinery spaces of category A are to be independent of systems serving other spaces.

5.2.5 Ventilation exhaust systems serving galleys are to be independent of systems serving other spaces. The galley ventilation exhaust systems need not be completely separated, but may be served by separate ducts from a ventilation unit serving other spaces if an automatic fire damper is fitted in the galley ventilation duct near the ventilation unit. Ventilation exhaust ducts serving galleys are to be of non-combustible material.

Section 5 Fire Fighting for Yachts of less than 500 GT

1 General

1.1 Application

1.1.1 The present Section applies to yachts of less than 500 GT.

1.1.2 Yachts of less than 24 m in length

Requirements in [3.1], [4.2.1], [4.3.1], [4.3.2], [4.3.4] and [4.4] are applicable to yachts of less than 24 m in length.

1.1.3 Yachts of 24 m in length and over and of less than 500 GT

Requirements in [2], [3.2], [4.1], [4.2.2], [4.3.1], [4.3.3], [4.3.4] and [4.4] are applicable to yachts of 24 m in length and over and of less than 500 GT.

1.2 General requirements

1.2.1 If a fire-fighting system not required by this Section is installed, it is to comply with the relevant Articles of Ch 4, Sec 13.

2 Water supply systems

2.1 Application

2.1.1 The present Article applies only to yachts of 24 m in length and over.

2.2 Fire pumps

2.2.1 The water supply system is to be designed in accordance with Tab 1.

2.2.2 Sanitary, bilge, general service or any other pumps may be used as fire pumps if they comply with the requirements of this article and do not affect the ability to cope with pumping of the bilges. Fire pumps are to be so connected that they cannot be used for pumping oil or other flammable liquids.

The total capacity of the main fire pump(s) need not exceed 25 m^3/h and is not to be less than:

$$Q = 2,5[1 + 0,066(L(B + D))^{0,5}]^2$$

Q : Total capacity (in m^3/hour)

L : Length of the yacht (in m)

B : Greatest moulded breadth of the yacht (in m)

D : Moulded depth measured to the bulkhead deck at midship (in m).

When the main water supply for other fixed fire-extinguishing systems is from the fire pumps, the total capacity of the fire pumps is to be sufficient for the simultaneous use of:

- the minimum required number of jets of water at the required pressure from the fire main, and
- other fixed fire-extinguishing systems primarily fed by the fire main at their required output, or likely combination thereof.

Table 1 : Minimum water supply installation for yachts of 24 m in length and over

Equipment	Minimum number
FIRE PUMPS	
Main power pumps	1
Emergency fire pumps (portable pumps or independently driven power pumps)	1
FIRE HYDRANTS	
Sufficient number and so located that at least one powerful water jet can reach any normally accessible part of the yacht	X
FIRE HOSES (length < 18 m)	
With couplings and nozzles	≥ 3
HOSE NOZZLES	
Dual purpose (spray/jet) with 12 mm jet and integral shut-off. Jet may be reduced to 10 mm and shut-off omitted for hand pump hoses	X

2.2.3 Fire pumps are to be capable of supplying the hydrants referred to in Tab 1 at the required pressure of at least 2,3 bar. A sufficient number of fire hydrants and, if necessary, a fire main, fire hoses, nozzles and couplings are to be provided according to Tab 1.

2.2.4 Portable fire pumps

If fitted, portable fire pumps should comply with the following:

a) the pump should be self-priming

b) the total suction head and the net positive suction head of the pump should be determined taking account of actual operation, i.e. pump location when used

c) except for electric pumps, the pump set should have its own fuel tank of sufficient capacity to operate the pump for three hours. For electric pumps, their batteries should have sufficient capacity for three hours

d) except for electric pumps, details of the fuel type and storage location should be carefully considered. If the fuel type has a flashpoint below 60°C, further consideration to the fire safety aspects should be given

e) the pump set should be stored in a secure, safe and enclosed space, accessible from open deck and outside of Category A machinery spaces

f) the pump set should be easily moved and operated by two persons and be readily available for immediate use

g) arrangements should be provided to secure the pump at its anticipated operating position(s)

h) the overboard suction hose should be non-collapsible and of sufficient length, to ensure suction under all operating conditions. A suitable strainer should be fitted at the inlet end of the hose

i) any diesel-driven power source for the pump should be capable of being readily started in its cold condition by hand (manual) cranking. If this is impracticable, consideration should be given to the provision and maintenance of heating arrangements, so that readily starting can be ensured

j) means to illuminate the stowage area of the portable pump and its necessary areas of operation should be provided from the emergency source of electrical power.

2.2.5 Independently driven power pumps

If fitted, independently driven power pumps should comply with the following:

a) the pump, its source of power and sea connection should be located in accessible positions, outside the machinery space housing the main fire pump

b) the sea valve should be capable of being operated from a position near the pump

c) the room where the fire pump prime mover is located should be illuminated from the emergency source of electrical power, and should be well ventilated

d) an isolating valve should be fitted in the fire main so that all the hydrants in the vessel, except that or those in the machinery space housing the main fire pump, can be supplied with water. The isolating valve should be located in an easily accessible and tenable position outside the machinery space housing the main fire pump; and the fire main should not re-enter the machinery space downstream of the isolating valve.

e) the pump set should be supplied with a source of energy independent from the one supplying the main fire pump and of sufficient capacity to operate the pump for two hours.

2.2.6 Pipes and hydrants

Materials readily rendered ineffective by heat should not be used for fire mains. Where steel pipes are used, they should be galvanized internally and externally. Cast iron pipes are not acceptable. The pipes and hydrants should be so placed that the fire-hoses may be easily coupled to them. The arrangement of pipes and hydrants should be such as to avoid the possibility of freezing. A valve should be fitted at each fire hydrant so that any fire-hose may be removed while the fire pump is at work.

3 Fire-extinguishing arrangements in machinery spaces

3.1 Yachts of less than 24 m in length

3.1.1 Fire-extinguishing arrangement for engine spaces containing diesel engines

The fire-extinguishing arrangement in the machinery spaces of category A is to be in accordance with Tab 2.

Table 2 : Protection of the engine space for diesel engines of yachts of less than 24 m in length

Combined rating (main and auxiliaries) of diesel engine	Protection achieved by:
≤ 120 kW	• fixed fire-extinguishing system, or • portable fire extinguisher of a type and size suitable to flood the engine space through a fire port in the engine casing
> 120 kW	• fixed fire-extinguishing system

Table 3 : Portable fire extinguisher arrangement in machinery spaces of category A for yachts of 24 m in length and over

Portable fire extinguishers (in compliance with Ch 4, Sec 13, [2])	Number
Spaces containing internal combustion engines (one extinguisher per 375 kW of internal combustion engine power)	minimum 2, maximum 4
Other machinery spaces of category A	1

3.1.2 Fire-extinguishing arrangement for engine spaces containing gasoline engines

The protection of the machinery spaces of category A is to be achieved by a fixed fire-extinguishing system.

3.1.3 Types of fire-extinguishing systems

a) A fixed fire extinguishing system required by [3.1.1] and [3.1.2] may be a fixed gas fire-extinguishing system complying with the provisions of Ch 4, Sec 13, [3]. The fixed fire extinguishing system should generally activate manually. It may also activate automatically, if installed in such a small engine space that it is not possible for someone to enter it. In this case, ventilation fans stops, closure of openings and fuel oil pump stops should also be activated automatically upon fixed fire-extinguishing system activation and means for manual activation of the system are to be additionally available.

b) A portable fire extinguisher system required by [3.1.1] may be a system with dry powder as extinguishing medium, contained in a fixed cylinder under pressure of nitrogen and fitted with a nozzle with opening both automatic and manually remote controlled from outside the corresponding space.

3.1.4 Portable fire extinguisher

One portable fire extinguisher in compliance with Ch 4, Sec 13, [2] is to be dedicated to the protection of each engine space.

3.2 Yachts of 24 m in length and over

3.2.1 Fixed fire-extinguishing systems

A fixed fire-extinguishing system is to be provided in the machinery spaces of category A.

3.2.2 Types of fixed fire-extinguishing systems

A fixed fire extinguishing system required by [3.2.1] may be any of the following systems:

a) a fixed gas fire-extinguishing system complying with the provisions of Ch 4, Sec 13, [3]

b) a fixed pressure water-spraying fire-extinguishing system complying with the provisions of Ch 4, Sec 13, [4].

3.2.3 Fire extinguisher arrangement

The fire extinguisher arrangement in machinery spaces of category A is to be provided in accordance with Tab 3.

4 Fire-extinguishing arrangements in accommodation and service spaces

4.1 Sprinkler systems

4.1.1 If fitted, the automatic sprinkler, fire detection and fire alarm systems are to be designed in accordance with Ch 4, Sec 13, [5].

4.1.2 Protection of saunas

Saunas, if any, are to comply with the requirements of Ch 4, Sec 2, [2.3.3].

4.2 Portable fire extinguishers

4.2.1 Yachts of less than 24 m in length

a) Portable fire extinguishers of the carbon dioxide type are not to be located or provided for use in accommodation spaces. Extinguishers are to be stowed in readily accessible and marked locations.

b) The portable fire extinguishers arrangement is to be in accordance with Tab 4. Portable fire extinguishers are to be in compliance with Ch 4, Sec 13, [2].

4.2.2 Yachts of 24 m in length and over

a) A minimum of at least 3 portable fire extinguishers are to be provided within accommodation and service spaces. As far as practical, the fire extinguishers provided are to have a uniform method of operation and are to be of an approved type and capacity. Portable fire extinguishers are to be in compliance with Ch 4, Sec 13, [2].

b) The number, location, fire extinguishing medium type and capacity are to be selected according to the perceived fire risk, but for each deck, one portable extinguisher should be available for use within a distance of 10 m from any location.

c) Portable fire extinguishers of the carbon dioxide type are not to be located or provided for use in accommodation spaces, except for use at the wheelhouse. Extinguishers are to be stowed in readily accessible and marked locations.

Table 4 : Portable fire extinguisher arrangement for yachts of less than 24 m in length

<table>
<tr><td rowspan="2">Type of area</td><td>L < 10 m</td><td>10 m ≤ L ≤ 15 m</td><td>15 m < L < 24 m</td></tr>
<tr><td colspan="3">at least one portable fire extinguisher is to be located within:</td></tr>
<tr><td>Main helm position or cockpit</td><td>• 1,0 m</td><td>• 2,5 m</td><td>• 2,0 m unobstructed distance</td></tr>
<tr><td>Accommodation area</td><td colspan="2">• 5,0 m from the centre of a berth **(1)**</td><td>• L/3 from the centre of any berth, measured in the horizontal projection **(1)**
• each 20 m² of the accommodation area **(1)**</td></tr>
<tr><td>Cooking area</td><td colspan="3">See [4.3.2]</td></tr>
<tr><td colspan="4">**(1)** If an accommodation area is protected by an automatic sprinkler system as mentioned in [4.1], only one portable fire extinguisher is to be provided in that accommodation area.
Note 1: A single extinguisher may meet more than one requirement of this Table.</td></tr>
</table>

4.3 Specific requirements for galleys

4.3.1 General

Galley equipment is to comply with Ch 4, Sec 2, [2.2] and ventilation system for galley on yachts of 24 m in length and over is to comply with Ch 4, Sec 4, [5.2.5].

4.3.2 Fire-extinguishing arrangement for yachts of less than 24 m in length

The following portable equipment is required near the cooking appliances:

a) one portable fire extinguisher, in compliance with Ch 4, Sec 13, [2] located inside the galley near to the entrance to the space. This portable fire extinguisher can be one of the portable fire extinguishers required in Tab 4

b) one fire blanket.

For yachts of less than 15 m in length, only one portable fire extinguisher as required in item a) or only one fire blanket as required in item b) may be accepted.

4.3.3 Portable fire equipment on yachts of 24 m in length and over

The following portable equipment is required in galleys:

a) one portable fire extinguisher, located inside the galley near to the entrance to the space. This portable fire extinguisher can be comprised in the 3 minimum portable fire extinguishers required on board according to [4.2.2], item a), but is considered in addition to the portable fire extinguisher provided for each deck according to [4.2.2], item b)

b) one fire blanket.

4.3.4 Deep-fat cooking equipment

Deep-fat cooking equipment, if any, is to be fitted with the following:

a) an automatic or manual fire-extinguishing system tested to an international standard

b) a primary and backup thermostat with an alarm to alert the operator in the event of failure of either thermostat

c) arrangements for automatically shutting off the electrical power upon activation of the fire-extinguishing system

d) an alarm for indicating operation of the fire-extinguishing system in the galley where the equipment is installed

e) controls for manual operation of the fire-extinguishing system which are clearly labelled for ready use by the crew.

4.4 Specific requirements for spaces containing flammable products

4.4.1 Paint lockers and flammable liquid lockers are to be protected by:

a) a carbon dioxide system, designed to give a minimum volume of free gas equal to 40% of the gross volume of the protected space

b) a dry powder system, designed for at least 0,5 kg powder/m^3

c) a water spraying or sprinkler system, designed for 5 l/m^2 min. Water spraying systems may be connected to the fire main of the yacht

d) a portable carbon dioxide fire extinguisher sized to provide a minimum volume of free gas equal to 40% of the gross volume of the space. A discharge port is to be arranged in the locker to allow the discharge of the extinguisher without having to enter into the protected space. The required portable fire extinguisher is to be stowed adjacent to the port, or

e) a port or hose connection may be provided to facilitate the use of fire main water.

In all cases, the system is to be operable from outside the protected space.

Section 6 Escape for Yachts of less than 500 GT

1 General

1.1 Application

1.1.1 The present Section applies to yachts of less than 500 GT.

1.1.2 Yachts of less than 24 m in length

Requirements in [1.2] and [2] are applicable to yachts of less than 24 m in length.

1.1.3 Yachts of 24 m in length and over and of less than 500 GT

Requirements in [1.2] and [3] are applicable to yachts of 24 m in length and over and of less than 500 GT.

1.2 General requirements

1.2.1 Different types of means of escape

Stairways, ladders, hatches and corridors serving all spaces normally accessible are to be so arranged as to provide ready means of escape to a deck from which embarkation into survival craft may be effected.

1.2.2 Lifts

Lifts are not to be considered as forming one of the means of escape as required by this Section.

1.2.3 Deck hatches

Where deck hatches are designated as exits, footholds, ladders, steps or other means are to be provided. These aids are to be permanently installed and non-removable. The vertical distance between the upper foothold and the exit is not to exceed 1,2 m.

The securing devices of hatches are to be of type which can be opened from both sides.

1.2.4 Minimum clear openings

Any exit from an accommodation space or from any other space is to have the following minimum clear openings:

a) circular shape: diameter 450 mm

b) any other shape: minimum dimensions of 380 mm and minimum area 0,18 m^2. The dimensions must be large enough to allow for a 380 mm diameter circle to be inscribed.

The measurement of the minimum clear opening is detailed in ISO 9094-1.

1.2.5 Shower and toilets

Shower and toilet compartments are regarded as part of the compartment or passageway that gives access to their doors and therefore do not require alternative escape routes.

1.2.6 Accessibility of escape routes

Escape routes are to be maintained in a safe condition, clear of obstacles.

1.2.7 Furniture along escape routes

No escape route are to be obstructed by furniture or fittings. Additionally, furniture along escape routes are to be secured in place to prevent shifting if the yacht rolls or lists.

2 Yachts of less than 24 m in length

2.1 Means of escape

2.1.1 Escape route arrangement

Arrangement of the escape routes is to be in accordance with Tab 1.

2.1.2 Accessibility of the exits

Exits are to be readily accessible. Exits leading to the weather deck or to the open air are to be capable of being opened from the inside and outside when secured and unlocked.

2.1.3 Marking of the exits

Escape facilities, unless self-evident, or doors are to be identified by the appropriate ISO or national symbol.

Table 1 : Arrangement of means of escape on board yachts of less than 24 m in length

	L ≤ 15m	L > 15m
Maximal distance to the nearest exit	• 5 m • 4 m where the exit route passes beside an machinery spaces of category A **(1)**	• L/3 for open-accommodation arrangements **(1)** **(2)**
Cases where a second escape route is required	• where the only one escape route is passing directly over a cooker • where living or sleeping accommodation is separated from the nearest exit by a solid partition (e.g. a door) and leads directly past a cooker or machinery spaces of category A	• where the distance between a cooking or open-flame heating-appliance burner and the nearest side of an escape route is less than 750 mm. In an enclosed galley, this requirement does not apply where the dead end beyond the cooker is less than 2 m
Escape route properties	• where only one escape route is provided, it is not to pass directly over a cooker	• where there are two escape routes only, one may pass through, over and beside an machinery spaces of category A • no escape route is to pass directly over a cooking or open-flame heating appliance
Enclosed accommodation arrangement **(3)**		• each accommodation section is to have more than one escape route leading finally to the open air, unless it is a single cabin or compartment intended to accommodate no more than four persons and the exit leads directly to the open air without passing through or over an machinery spaces of category A or over cooking appliances. The cabin must not contain cooking or open-flame heating devices • for individual cabins intended to accommodate no more than four persons, and not containing cooking or open-flame heating devices, escape routes may form shared escape ways for up to 2 m, measured to a two-way escape route from the door or entrance • with multilevel arrangements, the exits are to lead to a different accommodation section or compartment, as far as practicable

(1) The distance is to be measured in the horizontal plane as the shortest distance between the nearest part of the exit and:
- the farthest point where a person can stand (minimum height 1,60 m), or
- the midpoint of a berth, whichever is the greater distance.

(2) Open-accommodation arrangement: where living or sleeping accommodation is not separated from the nearest exit, i.e. people can move around without passing through any door. Doors of toilet or shower compartments are disregarded.

(3) Enclosed accommodation arrangement: where living or sleeping accommodation is separated from the nearest main exit by bulkheads and doors.

3 Yachts of 24 m in length and over

3.1 Means of escape from accommodation and service spaces

3.1.1 General

At all levels of accommodation, at least two widely separated means of escape from each restricted space or group of spaces are to be provided.

3.1.2 Escape from spaces below the open deck

The means of escape from accommodation and service spaces below the open deck is to be arranged so that it is possible to reach the open deck without passing through a galley or a machinery space of category A or other space with a high fire risk, wherever practicable.

3.1.3 Dead-end corridors

As a rule, dead-end corridors are not accepted.

3.1.4 Dispensation from two means of escape

Exceptionally the Society may dispense with one of the means of escape, for service spaces that are entered only occasionally, if the required escape route does not pass through a galley, machinery space or watertight door.

3.1.5 Doors in escape routes

All doors in escape routes are to be openable from either side. In the direction of escape they are all to be openable without a key. All handles on the inside of weathertight doors and hatches are to be non removable. Where doors are lockable measures to ensure access from outside the space are to be provided for rescue purposes.

3.1.6 Marking of the escape routes

Concealed escapes and escape routes are to be clearly marked to ensure ready exit by means of the appropriate ISO or national symbol.

3.2 Means of escape from machinery spaces

3.2.1 Category A machinery spaces

a) Category A machinery spaces should normally be provided with at least two means of escape, as widely separated as possible. Both means of escape are to be located from each side of the main fire risk (for example, the engines).

b) Exceptionally, only one means of escape may be provided, if it is not possible for a person to walk in the space more than 5 m in any direction.

c) One of the means of escape from machinery spaces of Category A is to have preferably a minimum clear opening of 600 x 600 mm or of diameter 600 mm.

3.2.2 Other machinery spaces

Other machinery spaces are to be provided with at least one means of escape.

Section 7 Containment of Fire for Yachts of 500 GT and over

1 General

1.1 Application

1.1.1 The present Section applies only to yachts of 500 GT and over.

2 Thermal and structural boundaries

2.1 Thermal and structural subdivision

2.1.1 Yachts are to be subdivided into spaces by thermal and structural divisions having regard to the fire risk of the space.

2.1.2 Main vertical zones and horizontal zones

a) The hull, superstructure and deckhouses in way of accommodation and service spaces are to be subdivided into main vertical zones by A class divisions or equivalent. These divisions are to have insulation values in accordance with Tab 1 and Tab 2.

b) As far as practicable, the bulkheads forming the boundaries of the main vertical zones above the bulkhead deck are to be in line with watertight subdivision bulkheads situated immediately below the bulkhead deck. The length and width of main vertical zones may be extended to a maximum of 48 m in order to bring the ends of main vertical zones to coincide with watertight subdivision bulkheads or in order to accommodate a large public space extending for the whole length of the main vertical zone provided that the total area of the main vertical zone is not greater than 1600 m^2 on any deck. The length or width of a main vertical zone is the maximum distance between the furthermost points of the bulkheads bounding it.

   If a stairway serves two main vertical zones, the maximum length of any one main vertical zone need not be measured from the far side of the stairway enclosure. In this case all boundaries of the stairway enclosure are to be insulated as main vertical zone bulkheads and access doors leading into the stairway are to be provided from the two outside zones. The number of main vertical zones of 48 m length is not limited as long as they comply with all the requirements.

c) Such bulkheads are to extend from deck to deck and to the shell or other boundaries.

2.1.3 Bulkheads within a main vertical zone

a) Bulkheads within accommodation and service spaces which are not required to be A class divisions or equivalent are to be at least B class or C class divisions as prescribed in Tab 1 and Tab 2. In addition, corridor bulkheads, where not required to be A class or equivalent, are to be B class divisions which are to extend from deck to deck except:

   1) when continuous B class ceilings or linings are fitted on both sides of the bulkhead, the portion of the bulkhead behind the continuous ceiling or lining is to be of material which, in thickness and composition, is acceptable in the construction of B class divisions, but which is required to meet B class integrity standards only in so far as is reasonable and practicable in the opinion of the Society, and

   2) in the case of a yacht protected by an automatic sprinkler system complying with the provisions of Ch 4, Sec 13, [5], the corridor bulkheads may terminate at a ceiling in the corridor provided such bulkheads and ceilings are of B class standard in compliance with [2.1.4]. All doors and frames in such bulkheads are to be of non-combustible materials and are to have the same fire integrity as the bulkhead in which they are fitted.

b) Bulkheads required to be B class divisions, except corridor bulkheads as prescribed in item a) above, are to extend from deck to deck and to the shell or other boundaries. However, where a continuous B class ceiling or lining is fitted on both sides of a bulkhead which is at least of the same fire resistance as the adjoining bulkhead, the bulkhead may terminate at the continuous ceiling or lining.

c) Examples of acceptable arrangements of items a) and b) are shown in Tab 3.

d) For yachts protected by an automatic sprinkler system complying with the provisions of Ch 4, Sec 13, [5], and a fully addressable fire detection system complying with the provisions of Ch 4, Sec 13, [6], bulkheads which are not required to be A class, B class or C class divisions in Tab 1 and Tab 2 may be of combustible materials, as per Ch 4, Sec 2, [3.6.1]. Example of acceptable arrangement is shown in Fig 1.

Table 1 : Fire integrity of bulkheads separating adjacent spaces

SPACES		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations	(1)	A-0 [c]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	*	A-60
Corridors	(2)		C [e]	B-0 [e]	A-0 [a] B-0 [e]	B-0 [e]	A-60	A-0	A-15 A-0 [d]	*	A-15
Accommodation spaces	(3)			C [e]	A-0 [a] B-0 [e]	B-0 [e]	A-60	A-0	A-15 A-0 [d]	*	A-30 A-0 [d]
Stairways	(4)				A-0 [a] B-0 [e]	A-0 [a] B-0 [e]	A-60	A-0	A-15 A-0 [d]	*	A-15
Service spaces (low risk)	(5)					C [e]	A-60	A-0	A-0	*	A-0
Machinery spaces of category A	(6)						*	A-0	A-60	*	A-60
Other machinery spaces	(7)							A-0 [b]	A-0	*	A-0
Service spaces (high risk)	(8)								A-0 [b]	*	A-30
Open decks	(9)									–	A-0
Vehicle spaces	(10)										A-0

Note 1: (to be applied to Tab 1 and Tab 2, as appropriate)

[a] : For clarification as to which applies, see [2.1.3] and [2.1.5].

[b] : Where spaces are of the same numerical category and letter "b" appears, a bulkhead or deck of the rating shown in the Tables is only required when the adjacent spaces are for a different purpose, e.g. in category (8). A galley next to a galley does not require a bulkhead, but a galley next to a paint room requires an A-0 bulkhead.

[c] : Bulkheads separating the wheelhouse and chartroom from each other may have a B-0 rating.

[d] : See items b) 3) and b) 4) of [2.1.4].

[e] : For the application of item a) of [2.1.2], B-0 and C, where appearing in Tab 1, are to be read as A-0.

[f] : Fire insulation need not be fitted if the machinery space in category (7), in the opinion of the Society, has little or no fire risk.

* : Where an asterisk appears in the Tables, the division is required to be of steel or other equivalent material, but is not required to be of A class standard. However, where a deck, except in a category (9) space, is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flame and smoke. Divisions between control stations (emergency generators) and open decks may have air intake openings without means for closure, unless a fixed gas fire-extinguishing system is fitted.
For the application of item a) of [2.1.2], an asterisk, where appearing in Tab 2, except for category (9), is to be read as A-0.

Table 2 : Fire integrity of decks separating adjacent spaces

SPACE below		SPACE above									
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations	(1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	*	A-30
Corridors	(2)	A-0	*	*	A-0	*	A-60	A-0	A-0	*	A-0
Accommodation spaces	(3)	A-60	A-0	*	A-0	*	A-60	A-0	A-0	*	A-30 A-0 [d]
Stairways	(4)	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0	*	A-0
Service spaces (low risk)	(5)	A-15	A-0	A-0	A-0	*	A-60	A-0	A-0	*	A-0
Machinery spaces of category A	(6)	A-60	A-60	A-60	A-60	A-60	*	A-60 [f]	A-60	*	A-60
Other machinery spaces	(7)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	*	A-0
Service spaces (high risk)	(8)	A-60	A-30 A-0 [d]	A-30 A-0 [d]	A-30 A-0 [d]	A-0	A-60	A-0	A-0	*	A-0
Open decks	(9)	*	*	*	*	*	*	*	*	–	A-0
Vehicle spaces	(10)	A-60	A-15	A-30 A-0 [d]	A-15	A-0	A-30	A-0	A-30	A-0	A-0

Note 1: The notes in Tab 1 apply to Tab 2, as appropriate.

Table 3 : Minimum fire safety construction generally acceptable in accommodation spaces

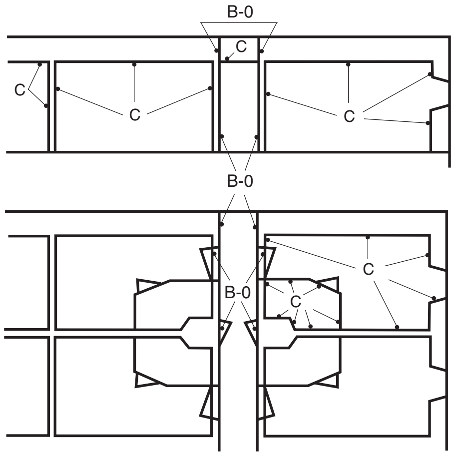
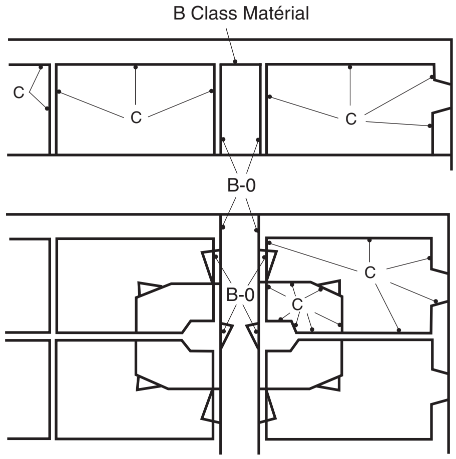
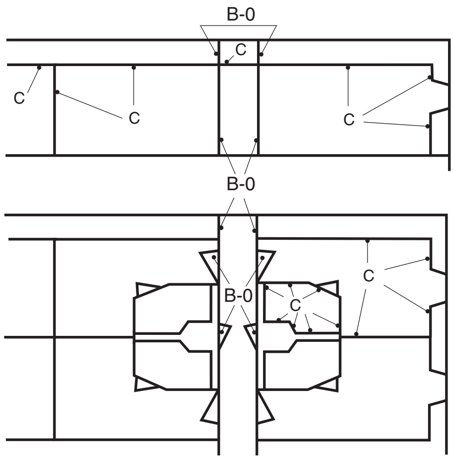
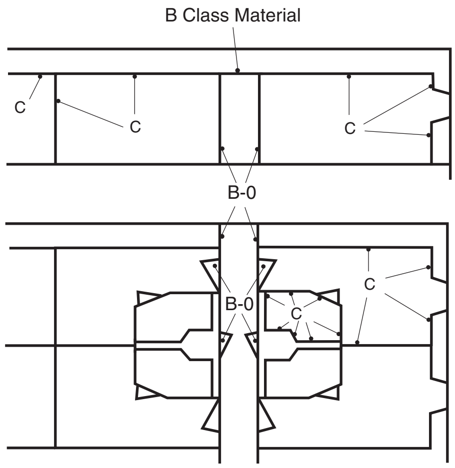
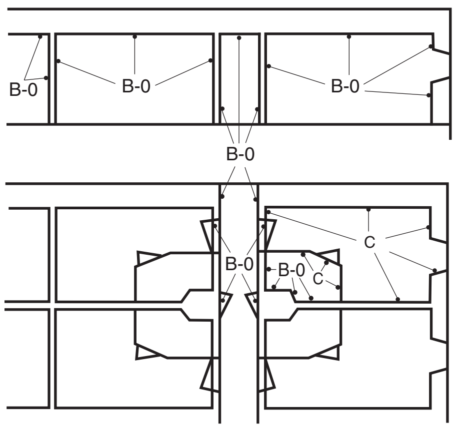
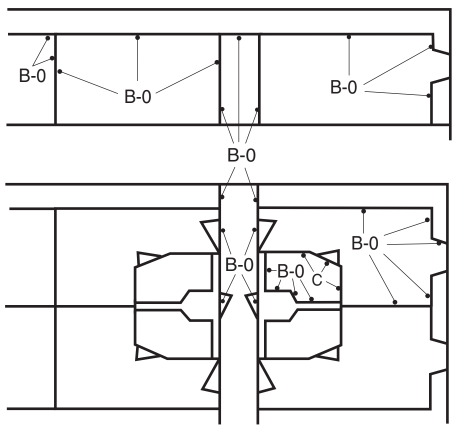
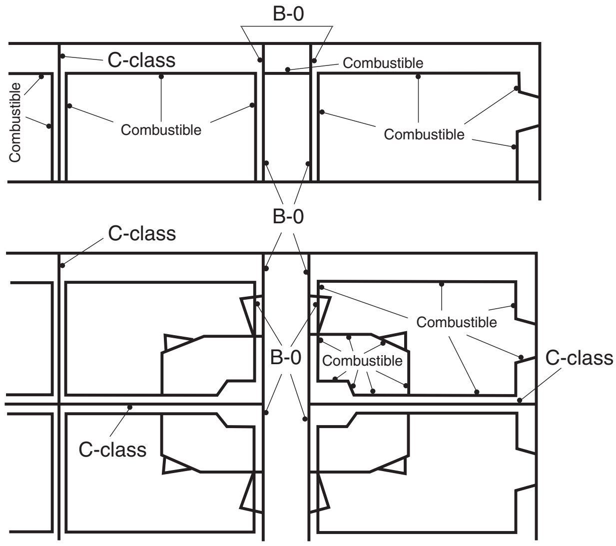
Possible B-class construction for all yachts	Possible B-class construction for yachts with automatic sprinkler system
 Option 1: B-0 corridor bulkheads from deck to deck with prefabricated C-class cabins	 Option 2: B-0 corridor bulkheads stopping at B-class material ceiling with prefabricated C-class cabins
 Option 3: B-0 corridor bulkheads from deck to deck and cabin bulkheads are common between corridors other cabins	 Option 4: B-0 corridor bulkheads stopping at B-class material ceiling and cabin bulkheads are common between corridors and other cabins
 Option 5: cabins and corridors of B-0 class continuous construction	 Option 6: cabins and corridors of B-0 class continuous construction but cabin bulkheads are common between corridors and other cabins

Figure 1 : Other possible B-class construction for yachts fitted with automatic sprinkler system and addressable fire detection system in accommodation spaces



2.1.4 Fire integrity of bulkheads and decks

a) In addition to complying with the specific provisions for fire integrity of bulkheads and decks mentioned in [2.1.2] and [2.1.3], the minimum fire integrity of bulkheads and decks is to be as prescribed in Tab 1 and Tab 2.

b) The following requirements govern application of the Tables:

1) Tab 1 and Tab 2 apply, respectively, to the bulkheads and decks separating adjacent spaces.

2) For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (10) below. Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of the present Section, or where it is possible to assign two or more classifications to a space, it is to be treated as a space within the relevant category having the most stringent boundary requirements. Smaller, enclosed rooms within a space that have less than 30 % communicating openings to that space are considered separate spaces. The fire integrity of the boundary bulkheads and decks of such smaller rooms is to be as prescribed in Tab 1 and Tab 2. The title of each category is intended to be typical rather than restrictive. The number in parentheses preceding each category refers to the applicable column or row in the Tables.

- (1) Control stations

  Spaces containing emergency sources of power and lighting

  Wheelhouse and chartroom

  Spaces containing the yacht's radio equipment

  Fire control stations

  Control room for propulsion machinery when located outside the machinery space

  Spaces containing centralized fire alarm equipment.

- (2) Corridors

  Passenger and crew corridors and lobbies.

- (3) Accommodation spaces

  Spaces as defined in Ch 4, Sec 1, [3.4.1] excluding corridors.

- (4) Stairways

  Interior stairways, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto.

  In this connection, a stairway which is enclosed only at one level is to be regarded as part of the space from which it is not separated by a fire door.

- (5) Service spaces (low risk)

  Lockers and store-rooms not having provisions for the storage of flammable liquids and having areas less than 4 m² and drying rooms and laundries.

- (6) Machinery spaces of category A

  Spaces as defined in Ch 4, Sec 1, [3.4.15].

- (7) Other machinery spaces

  Electrical equipment rooms (auto-telephone exchange, air-conditioning duct spaces)

  Spaces as defined in Ch 4, Sec 1, [3.4.14], excluding machinery spaces of category A.

- (8) Service spaces (high risk)

  Galleys, pantries containing cooking appliances, paint lockers, lockers and store-rooms having areas of 4 m^2 or more, spaces for the storage of flammable liquids, saunas and workshops other than those forming part of the machinery spaces.
- (9) Open decks

  Open deck spaces and enclosed promenades having little or no fire risk. Enclosed promenades are to have no significant fire risk, meaning that furnishing is to be restricted to deck furniture. In addition, such spaces are to be naturally ventilated by permanent openings.

  Air spaces (the space outside superstructures and deckhouses).
- (10) Vehicle spaces

  Spaces as defined in Ch 4, Sec 1, [3.4.24].

3) In determining the applicable fire integrity standard of a boundary between two spaces within a main vertical zone or horizontal zone which is not protected by an automatic sprinkler system complying with the provisions of Ch 4, Sec 13, [5] or between such zones neither of which is so protected, the higher of the two values given in the Tables applies.
4) In determining the applicable fire integrity standard of a boundary between two spaces within a main vertical zone or horizontal zone which is protected by an automatic sprinkler system complying with the provisions of Ch 4, Sec 13, [5] or between such zones both of which are so protected, the lesser of the two values given in the Tables applies. Where a zone with sprinklers and a zone without sprinklers meet within accommodation and service spaces, the higher of the two values given in the Tables applies to the division between the zones.

c) Continuous B class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

d) External boundaries which are required to be of steel or other equivalent material may be pierced for the fitting of windows and sidescuttles provided that there is no requirement for such boundaries to have A class integrity. Similarly, in such boundaries which are not required to have A class integrity, doors may be constructed of combustible materials.

e) In approving structural fire protection details, the Society has to have regard to the risk of heat transmission at intersections and terminal points of required thermal barriers.

f) Construction and arrangement of saunas and hammam rooms (steam rooms)

1) Saunas and hammam rooms, are to comply with Ch 4, Sec 2, [2.3.3] or Ch 4, Sec 2, [2.3.4], as applicable.
2) The perimeter of the sauna is to be of "A" class boundaries and may include changing rooms, showers and toilets. The sauna is to be insulated to "A-60" standard against other spaces except those inside of the perimeter and spaces of categories (7) and (9).
3) The perimeter of the hammam room is to be of "A" class boundaries and may include changing rooms, showers and toilets. The hammam room is to be insulated to "A-0" standard against other spaces except those inside of the perimeter and spaces of categories (7) and (9), if the steam generator is more than 5 kW and is contained within the hammam area. If the steam generator is more than 5 kW and is not contained within the hammam area, the boundaries are to be constructed of B-15 class divisions, and the steam generator is to be protected by A-0 class divisions.
4) Bathrooms with direct access to saunas/hammam rooms may be considered as part of them. In such cases, the door between sauna/hammam room and the bathroom need not comply with fire safety requirements.
5) If a sauna is comprised within the hammam area, the requirements of item f) 2) for saunas are applicable.

2.1.5 Protection of stairways and lifts in accommodation area

a) Stairways in accommodation and service spaces and control stations should be of steel frame construction except where the Society sanctions the use of other equivalent material, and should be within enclosures formed of A class divisions or equivalent, with positive means of closure at all openings, except that:

1) Stairways which penetrate only a single deck are to be protected, at a minimum, at one level by at least B-0 class divisions and self-closing doors. Lifts which penetrate only a single deck are to be surrounded by A-0 class divisions with steel doors at both levels. Stairways and lift trunks which penetrate more than a single deck are to be surrounded by at least A-0 class divisions and be protected by self-closing doors at all levels.

   On yachts having accommodation for 12 persons or less, where stairways penetrate more than a single deck and where there are at least two escape routes direct to the open deck at every accommodation level, the A-0 requirements of the above item a) may be reduced to B-0.

   The door provided at this stairway enclosure is to be of the self-closing type.
2) stairways may be fitted in the open in a public space, provided they lie wholly within the public space.

b) Direct access to stairway enclosures

Stairway enclosures in accommodation and service spaces are to have direct access from the corridors and be of a sufficient area to prevent congestion, having in view the number of persons likely to use them in an emergency. Only public spaces, corridors, lifts, toilets, crew cabins, lockers of non-combustible material providing storage for non-hazardous safety equipment, vehicle spaces, other escape stairways and external areas are permitted to have direct access to these stairway enclosures.

c) Lift trunks are to be so fitted as to prevent the passage of smoke and flame from one 'tweendeck to another and are to be provided with means of closing so as to permit the control of draught and smoke. Machinery for lifts located within stairway enclosures is to be arranged in a separate room, surrounded by steel boundaries, except that small passages for lift cables are permitted. Lifts which open into spaces other than corridors, public spaces, vehicle spaces, stairways and external areas are not to open into stairways included in the means of escape.

2.1.6 Arrangement of cabin balconies

Non-load bearing partial bulkheads which separate adjacent cabin balconies are to be capable of being opened by the crew from each side for the purpose of fighting fires.

3 Penetrations in fire-resisting divisions and prevention of heat transmission

3.1 Penetrations in A class divisions or equivalent

3.1.1 Where A class divisions or equivalent are penetrated, such penetration is to be tested in accordance with the Fire Test Procedures Code. In the case of ventilation ducts, requirements [7.2.2] and [7.4.1] apply. However, where a pipe penetration is made of steel or equivalent material having a thickness of 3 mm or greater and a length of not less than 900 mm (preferably 450 mm on each side of the division), and there are no openings, testing is not required. Such penetrations is to be suitably insulated by extension of the insulation at the same level of the division.

3.2 Penetrations in B class divisions

3.2.1 Where B class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., of for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements are to be made to ensure that the fire resistance is not impaired, subject to the provisions of [7.4.3]. Pipes other that steel or copper that penetrate B class divisions are to be protected by either:

- a fire-tested penetration device suitable for the fire resistance of the division pierced and the type of pipe used, or
- a steel sleeve, having a thickness of not less than 1,8 mm and a length of not less than 900 mm for pipe diameters of 150 mm or more and not less than 600 mm for pipe diameters of less than 150 mm (preferably equally divided to each side of the division). The pipe is to be connected to the ends of the sleeve by flanges or couplings; or the clearance between the sleeve and the pipe is not to exceed 2,5 mm; or any clearance between pipe and sleeve is to be made tight by means of non-combustible or other suitable material.

3.3 Pipes penetrating A or B class divisions

3.3.1 Uninsulated metallic pipes penetrating A or B class divisions are to be of materials having a melting temperature which exceeds 950°C for A-0 and 850°C for B-0 class divisions.

3.3.2 Where the Society may permit the conveying of oil and combustible liquids through accommodation and service spaces, the pipes conveying oil or combustible liquids are to be of a material approved by the Society having regard to the fire risk.

3.4 Prevention of heat transmission

3.4.1 In approving structural fire protection details, the Administration has to have regard to the risk of heat transmission at intersections and terminal points of required thermal barriers. The insulation of a deck or bulkhead is to be carried past the penetration, intersection or terminal point for a distance of at least 450 mm in the case of steel and aluminium structures. If a space is divided with a deck or a bulkhead of A class standard having insulation of different values, the insulation with the higher value is to continue on the deck or bulkhead with the insulation of the lesser value for a distance of at least 450 mm.

4 Protection of openings in fire-resisting divisions

4.1 Openings in bulkheads and decks

4.1.1 Openings in A class divisions or equivalent

a) Openings are to be provided with permanently attached means of closing which are to be at least as effective for resisting fires as the divisions in which they are fitted.

b) The construction of doors and door frames in A class divisions or equivalent, with the means of securing them when closed, is to provide resistance to fire as well as to the passage of smoke and flame equivalent to that of the bulkheads in which the doors are situated, this being determined in accordance with the Fire Test Procedures Code. Such doors and door frames are to be constructed of steel or other equivalent material. Watertight doors need not be insulated.

c) It is to be possible for each door to be opened and closed from each side of the bulkhead by one person only.

d) On board charter yachts having two or more main vertical zones containing accommodation spaces, fire doors in main vertical zone bulkheads, galley boundaries and stairway enclosures other than power-operated watertight doors and those which are normally locked are to satisfy the following requirements:

1) the doors are to be self-closing and be capable of closing with an angle of inclination of up to 3,5° opposing closure
2) the approximate time of closure for hinged fire doors is to be no more than 40 s and no less than 10 s from the beginning of their movement with the yacht in upright position. The approximate uniform rate of closure for sliding doors is to be of no more than 0,2 m/s and no less than 0,1 m/s with the yacht in upright position
3) the doors, except those for emergency escape trunks, are to be capable of remote release from the continuously manned central control station, either simultaneously or in groups, and are to be capable of release also individually from a position at both sides of the door. Release switches are to have an on-off function to prevent automatic resetting of the system
4) hold-back hooks not subject to central control station release are prohibited
5) a door closed remotely from the central control station is to be capable of being re-opened from both sides of the door by local control. After such local opening, the door is to automatically close again
6) indication is to be provided at the fire door indicator panel in the continuously manned central control station whether each door is closed
7) the release mechanism is to be so designed that the door will automatically close in the event of disruption of the control system or central power supply
8) local power accumulators for power-operated doors are to be provided in the immediate vicinity of the doors to enable the doors to be operated at least ten times (fully opened and closed) after disruption of the control system or central power supply using the local controls
9) disruption of the control system or central power supply at one door is not to impair the safe functioning of the other doors
10) remote-released sliding or power-operated doors are to be equipped with an alarm that sounds at least 5 s but no more than 10 s, after the door is released from the central control station and before the door begins to move and continues sounding until the door is completely closed
11) a door designed to re-open upon contacting an object in its path is to re-open not more than 1 m from the point of contact
12) double-leaf doors equipped with a latch necessary for their fire integrity are to have a latch that is automatically activated by the operation of the doors when released by the system
13) the components of the local control system are to be accessible for maintenance and adjusting
14) power-operated doors are to be provided with a control system of an approved type which is to be able to operate in case of fire and be in accordance with the Fire Test Procedures Code. This system is to satisfy the following requirements:
    - the control system is to be able to operate the door at the temperature of at least 200°C for at least 60 min, served by the power supply
    - the power supply for all other doors not subject to fire is not to be impaired, and
    - at temperatures exceeding 200°C, the control system is to be automatically isolated from the power supply and is to be capable of keeping the door closed up to at least 945°C.

e) On board the other charter yachts and on board yachts not engaged in trade having two or more main vertical zones containing accommodation spaces, fire doors in main vertical zone bulkheads, galley boundaries and stairway enclosures other than power-operated watertight doors and those which are normally locked need only to satisfy items d) 1), d) 2), d) 4) and d) 6) above.

4.1.2 Openings in B class divisions

a) Doors and door frames in B class divisions and means of securing them are to provide a method of closure which is to have resistance to fire equivalent to that of the divisions, this being determined in accordance with the Fire Test Procedures Code, except that ventilation openings may be permitted in the lower portion of such doors. Where such opening is in or under a door, the total net area of any such opening or openings is not to exceed 0,05 m^2. All ventilation openings are to be fitted with a grill made of non-combustible material. Doors are to be non-combustible.

b) Cabin doors in B class divisions are to be of a self-closing type. Hold-back hooks are not permitted.

c) For yachts protected by:

- an automatic sprinkler system complying with the provisions of Ch 4, Sec 13, [5], and
- a fully addressable fire detection system complying with the provisions of Ch 4, Sec 13, [6],

the Society may permit the use of combustible materials in doors separating cabins from the individual interior sanitary spaces such as showers.

4.1.3 Windows and sidescuttles

a) Windows and sidescuttles in bulkheads within accommodation and service spaces and control stations are to be so constructed as to preserve the integrity requirements of the type of bulkheads in which they are fitted, this being determined in accordance with the Fire Test Procedures Code.

b) Glass is not to be installed as an interior main vertical zone, stairway enclosure bulkhead, or within machinery spaces boundaries.

5 Protection of openings in machinery space boundaries

5.1 Application

5.1.1 The provisions of Article [5] are applicable to machinery spaces of category A and, where the Society considers it desirable, to other machinery spaces.

5.2 Protection of openings in machinery space boundaries

5.2.1

a) The number of skylights, doors, ventilators, openings in funnels to permit exhaust ventilation and other openings to machinery spaces are to be reduced to a minimum consistent with the needs of ventilation and the proper and safe working of the yacht.

b) Skylights are to be of steel and are not to contain glass panels.

5.2.2 Means of control are to be provided for closing power-operated doors or actuating release mechanisms on doors other than power-operated watertight doors. The controls are to be located outside the space concerned, where they will not be cut off in the event of fire in the space they serve.

5.2.3 When access to any machinery space of category A is provided at a low level from an adjacent shaft tunnel, there is to be provided in the shaft tunnel, near the watertight door, a light steel fire-screen door operable from each side.

5.2.4 Windows are not to be fitted in machinery space boundaries. However, this does not preclude the use of glass in control rooms within the machinery spaces.

6 Control of smoke spread

6.1 Draught stops

6.1.1 Air spaces enclosed behind ceilings, panelling or linings are to be divided by close-fitting draught stops spaced not more than 14 m apart. In the vertical direction, such enclosed air spaces, including those behind linings of stairways, trunks, etc., are to be closed at each deck.

7 Ventilation systems

7.1 Ventilation controls

7.1.1 Closing appliances and stopping devices of ventilation

a) The main inlets and outlets of all ventilation systems are to be capable of being closed from outside the spaces being ventilated. The means of closing are to be easily accessible as well as prominently and permanently marked and are to indicate whether the shut-off is open or closed.

   Ventilation inlets and outlets located at outside boundaries are to be fitted with closing appliances as required above and need not comply with [7.4.1].

b) Power ventilation of accommodation spaces, service spaces, control stations and machinery spaces is to be capable of being stopped from an easily accessible position outside the space being served. This position is not to be readily cut off in the event of a fire in the spaces served.

7.1.2 Means of control in machinery spaces

a) Means of control are to be provided for opening and closure of skylights, closure of openings in funnels which normally allow exhaust ventilation and closure of ventilator dampers.

b) Means of control are to be provided for stopping ventilating fans. Controls provided for the power ventilation serving machinery spaces are to be grouped so as to be operable from two positions, one of which is to be outside such spaces. The means provided for stopping the power ventilation of the machinery spaces are to be entirely separate from the means provided for stopping ventilation of other spaces.

c) Means of control are to be provided for stopping forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers). However, items d) and e) hereafter need not apply to oily water separators.

d) The controls required in a) to c) above are to be located outside the space concerned so they will not be cut off in the event of fire in the space they serve.

In machinery spaces of category A, controls to close off ventilation ducts and pipes are to be installed with due regard to the hot gases produced by a fire in the space concerned.

e) The controls required in items a) to d) above and in [5.2.2] and the controls for any required fire-extinguishing system are to be situated at one control position or grouped in as few positions as possible to the satisfaction of the Society. Such positions are to have a safe access from the open deck.

7.2 Duct and dampers

7.2.1 Ventilation ducts are to be of non-combustible material. However, short ducts, not generally exceeding 2 m in length and with a free cross-sectional area not exceeding 0,02 m^2, need not be non-combustible, subject to the following conditions:

a) the ducts are made of a material which has low flame spread characteristics

b) the ducts are only used at the end of the ventilation device, and

c) the ducts are not situated less than 600 mm, measured along the duct, from an opening in an A or B class division, including continuous B class ceiling.

Flexible bellows of combustible material may be used for connecting fans to the ducting in the air conditioning room.

Combustible gaskets in flanged ventilation duct connections are not permitted within 600 mm of an opening in an A or B class divisions and in ducts required to be of A class construction.

7.2.2 The following arrangements are to be tested in accordance with the Fire Test Procedures Code:

a) fire dampers, including their relevant means of operation, and

b) duct penetrations through A class divisions or equivalent. However, the test is not required where steel sleeves are directly joined to ventilation ducts by means of riveted or screwed flanges or by welding.

7.3 Arrangements of ducts

7.3.1 The ventilation systems for machinery spaces of category A, vehicle spaces and galleys, are, in general, to be separated from each other and from the ventilation systems serving other spaces, except that the galley ventilation systems need not be completely separated, but may be served by separate ducts from a ventilation unit serving other spaces. In any case, an automatic fire damper is to be fitted in the galley ventilation duct near the ventilation unit. Ducts provided for the ventilation of machinery spaces of category A, galleys, vehicle spaces are not to pass through accommodation spaces, service spaces or control stations unless they comply with the conditions specified in items a) to d) or in items e) and f) below:

a) the ducts are constructed of steel having a thickness of at least 3 mm and 5 mm for ducts the widths or diameters of which are up to and including 300 mm and 760 mm and over, respectively, and, in the case of such ducts, the widths or diameters of which are between 300 mm and 760 mm, having a thickness obtained by interpolation

b) the ducts are suitably supported and stiffened

c) the ducts are fitted with automatic fire dampers close to the boundaries penetrated, and

d) the ducts are insulated to A-60 class standard from the machinery spaces, galleys or vehicle spaces to a point at least 5 m beyond each fire damper

or

e) the ducts are constructed of steel in accordance with the preceding items a) and b), and

f) the ducts are insulated to A-60 class standard throughout the accommodation spaces, service spaces or control stations,

except that penetrations of main zone divisions are also to comply with the requirements of [7.3.3].

Note 1: For determining fire insulation for trunks and ducts which pass through an enclosed space in [7.3.1] and [7.3.2], the term “pass through” pertains to the part of the trunk/duct contiguous to the enclosed space. Sketches are given as examples in the IMO Circular MSC.1/Circ. 1276, “Sketches of galley exhaust ducts from spaces”.

7.3.2 Ducts provided for ventilation to accommodation spaces, service spaces or control stations are not to pass through machinery spaces of category A, galleys or vehicle spaces unless they comply with the conditions specified in items a) to c) or in items d) and e) below:

a) the ducts, where they pass through a machinery space of category A, galley or vehicle space are constructed of steel in accordance with items a) and b) of [7.3.1]

b) automatic fire dampers are fitted close to the boundaries penetrated, and

c) the integrity of the machinery space, galley or vehicle space boundaries is maintained at the penetrations,

or

d) the ducts, where they pass through a machinery space of category A, galley or vehicle space are constructed of steel in accordance with items a) and b) of [7.3.1], and

e) the ducts are insulated to A-60 standard within the machinery space, galley or vehicle space,

except that penetrations of main zone divisions are also to comply with the requirements of [7.3.3].

7.3.3 Where it is necessary that a ventilation duct passes through a main vertical zone division, a fail-safe automatic closing fire damper is to be fitted adjacent to the division. The damper is also to be capable of being manually closed from each side of the division. The operating position is to be readily accessible and be marked in red light-reflecting colour. The duct between the division and the damper is to be of steel or other equivalent material. The damper is to be fitted on at least one side of the division with a visible indicator showing whether the damper is in the open position.

7.3.4 Balancing openings or ducts between two enclosed spaces are prohibited except for openings as permitted by item a) of [4.1.2].

7.4 Details of duct penetrations

7.4.1 Where a thin plated duct with a free cross-sectional area equal to, or less than, 0,02 m^2 passes through A class bulkheads or decks, the opening is to be lined with a steel sheet sleeve having a thickness of at least 3 mm and a length of at least 200 mm, divided preferably into 100 mm on each side of the bulkhead or, in the case of the deck, wholly laid on the lower side of the decks pierced. Where ventilation ducts with a free cross-sectional area exceeding 0,02 m^2 pass through A class bulkheads or decks, the opening is to be lined with a steel sheet sleeve. However, where such ducts are of steel construction and pass through a deck or bulkhead, the ducts and sleeves are to comply with the following:

a) The sleeves are to have a thickness of at least 3 mm and a length of at least 900 mm. When passing through bulkheads, this length is to be divided preferably into 450 mm on each side of the bulkhead. These ducts, or sleeves lining such ducts, are to be provided with fire insulation. The insulation is to have at least the same fire integrity as the bulkhead or deck through which the duct passes.

   Equivalent penetration protection may be provided to the satisfaction of the Society, and

b) Ducts with a free cross-sectional area exceeding 0,075 m^2 are to be fitted with fire dampers in addition to the requirements of item a) just above. The fire damper is to operate automatically, but is also to be capable of being closed manually from both sides of the bulkhead or deck. The damper is to be provided with an indicator which shows whether the damper is open or closed. Fire dampers are not required, however, where ducts pass through spaces surrounded by A class divisions or equivalent, without serving those spaces, provided those ducts have the same fire integrity as the divisions which they pierce. Fire dampers are to be easily accessible. Where they are placed behind ceilings or linings, these ceilings or linings are to be provided with an inspection door on which a plate reporting the identification number of the fire damper is provided. The fire damper identification number is also to be placed on any remote controls required.

7.4.2 With reference to the requirements of [7.4.1], the following applies:

The term "free cross-sectional area" means, even in the case of a pre-insulated duct, the area calculated on the basis of the inner diameter of the duct.

7.4.3 Ventilation ducts with a free cross-sectional area exceeding 0,02 m^2 passing through B class bulkheads are to be lined with steel sheet sleeves of 900 mm in length, divided preferably into 450 mm on each side of the bulkheads unless the duct is of steel for this length.

7.5 Exhaust ducts from galley ranges

7.5.1 Where they pass through accommodation spaces or spaces containing combustible materials, the exhaust ducts from galley ranges are to be constructed of A class divisions or equivalent. In addition, each exhaust duct is to be fitted with:

a) a grease trap readily removable for cleaning

b) a fire damper located in the lower end of the duct, in addition, a fire damper in the upper end of the duct

c) arrangements, operable from within the galley, for shutting off the exhaust fans,

d) fixed means for extinguishing a fire within the duct, and

e) locals controls to activate fire-extinguishing system, stop the fan and close the fire dampers, grouped in one position immediately outside the main entrance to the galley.

Note 1: The term "pass through" pertains to the part of the trunk/duct contiguous to the enclosed space. Sketches are given as examples in the IMO Circular MSC.1/Circ. 1276, "Sketches of galley exhaust ducts from spaces".

7.6 Protection of control stations outside machinery spaces

7.6.1 Practicable measures are to be taken for control stations outside machinery spaces in order to ensure that ventilation, visibility and freedom from smoke are maintained so that, in the event of fire, the machinery and equipment contained therein may be supervised and continue to function effectively. Alternative and separate means of air supply are to be provided and air inlets of the two sources of supply are to be so disposed that the risk of both inlets drawing in smoke simultaneously is minimized.

At the discretion of the Society, such requirements need not apply to control stations situated on, and opening onto, an open deck or where local closing arrangements would be equally effective.

7.6.2 Equally effective local closing arrangements means that in the case of ventilators these are to be fitted with fire dampers or smoke dampers which are to be easily closed within the control station in order to maintain the absence of smoke in the event of fire.

Section 8 Fire Fighting for Yachts of 500 GT and over

1 General

1.1 Application

1.1.1 The present Section applies only to yachts of 500 GT and over.

2 Water supply systems

2.1 General

2.1.1 Yachts are to be provided with fire pumps, fire mains, hydrants and hoses complying with the applicable requirements of this Section.

2.2 Fire mains and hydrants

2.2.1 General

Materials readily rendered ineffective by heat are not to be used for fire mains and hydrants unless adequately protected. The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. The arrangement of pipes and hydrants are to be such as to avoid the possibility of freezing. Suitable drainage provisions are to be provided for fire main piping. Isolation valves are to be installed for all open deck fire main branches used for purposes other than fire fighting.

2.2.2 Ready availability of water supply

With a periodically unattended machinery space or when only one person is required on watch, there is to be immediate water delivery from the fire main system at a suitable pressure, either by remote starting of one of the main fire pumps with remote starting from the navigation bridge and fire control station, if any, or permanent pressurization of the fire main system by one of the main fire pumps, except that the Society may waive this requirement for yachts of less than 1600 gross tonnage if the fire pump starting arrangement in the machinery space is in an easily accessible position.

2.2.3 Diameter of fire mains

The diameter of the fire main and water service pipes is to be sufficient for the effective distribution of the maximum required discharge from two fire pumps operating simultaneously, except that the diameter need only be sufficient for the discharge of 140 m^3/hour.

2.2.4 Isolating valves and relief valves

a) Isolating valves to separate the section of the fire main within the machinery space containing the main fire pump or pumps from the rest of the fire main are to be fitted in an easily accessible and tenable position outside the machinery spaces. The fire main is to be so arranged that when the isolating valves are shut all the hydrants on the ship, except those in the machinery space referred to above, can be supplied with water by another fire pump or an emergency fire pump. The emergency fire pump, its seawater inlet, and suction and delivery pipes and isolating valves are to be located outside the machinery space. If this arrangement cannot be made, the sea-chest may be fitted in the machinery space if the valve is remotely controlled from a position in the same compartment as the emergency fire pump and the suction pipe is as short as practicable. Short lengths of suction or discharge piping may penetrate the machinery space, provided they are enclosed in a substantial steel casing or are insulated to A-60 class standards. The pipes are to have substantial wall thickness, but in no case less than 11 mm, and are to be welded except for the flanged connection to the sea inlet valve.

b) A valve is to be fitted to serve each fire hydrant so that any fire hose may be removed while the fire pumps are in operation.

c) Relief valves are to be provided in conjunction with fire pumps if the pumps are capable of developing a pressure exceeding the design pressure of the water service pipes, hydrants and hoses. These valves are to be so placed and adjusted as to prevent excessive pressure in any part of the fire main system.

2.2.5 Number and position of hydrants

The number and position of hydrants are to be such that at least two jets of water not emanating from the same hydrant, one of which is to be from a single length of hose, may reach any part of the ship normally accessible to the passengers or crew while the ship is being navigated and any vehicle space, in which latter case the two jets are to reach any part of the space, each from a single length of hose. Furthermore, such hydrants are to be positioned near the accesses to the protected spaces.

At least two hydrants are to be provided in machinery spaces of category A.

2.2.6 Pressure at hydrants

a) With the two pumps simultaneously delivering water through the nozzles specified in [2.2.3], with the quantity of water as specified in [2.4.3], through any adjacent hydrants, the following minimum pressures are to be maintained at all hydrants:

- in yachts of 6000 GT and upwards ...... 0,27 N/mm^2
- in yachts less than 6000 GT .... 0,25 N/mm^2

b) The maximum pressure at any hydrant are not to exceed that at which the effective control of a fire hose can be demonstrated.

2.2.7 International shore connection

a) Yachts are to be provided with at least one international shore connection. Facilities are to be available enabling such a connection to be used on either side of the ship.

b) Standard dimensions of flanges for the international shore connection are to be in accordance with Tab 1 (see also Fig 1).

c) International shore connections are to be of steel or other equivalent material and are to be designed for 1,0 N/mm^2 services. The flange has to have a flat face on one side and, on the other side, it is to be permanently attached to a coupling that will fit the ship's hydrant and hose. The connection is to be kept aboard the ship together with a gasket of any material suitable for 1,0 N/mm^2 services, together with four bolts of 16 mm diameter and 50 mm in length, four 16 mm nuts and eight washers.

Figure 1 : International shore connection

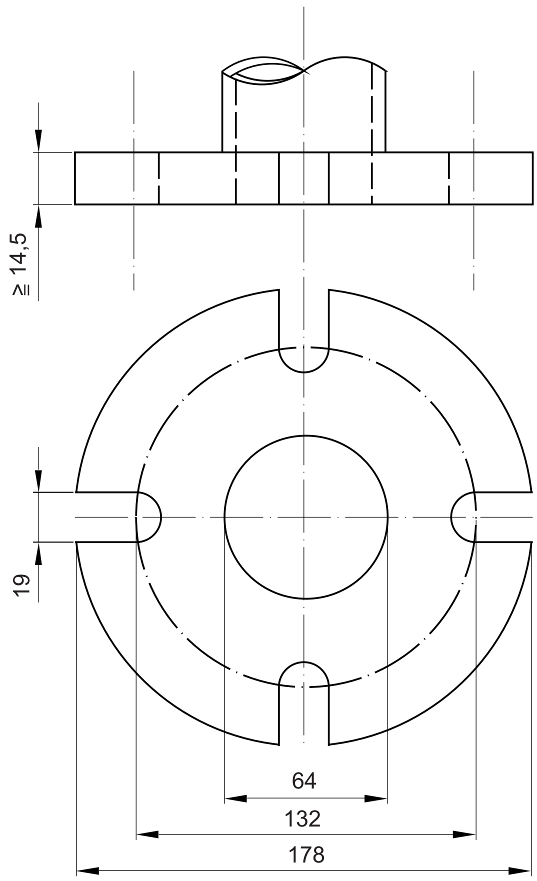


Table 1 : Standard dimensions

Description	Dimensions
Outside diameter	178 mm
Inside diameter	64 mm
Bolt circle diameter	132 mm
Slots in flange	4 holes, 19 mm diameter, spaced equidistantly on a bolt circle of the above diameter, slotted to the flange periphery
Flange thickness	14,5 mm minimum
Bolts and nuts	4, each of 16 mm diameter, 50 mm length

2.3 Fire pumps

2.3.1 Pumps accepted as fire pumps

Sanitary, ballast, bilge or general service pumps may be accepted as fire pumps, provided that they are not normally used for pumping oil and that, if they are subject to occasional duty for the transfer or pumping of oil fuel, suitable change-over arrangements are fitted.

2.3.2 Number and type of fire pumps

a) Yachts are to be provided with fire pumps, as follows:
   - in yachts of 1000 GT and upwards: at least 2 independently driven fire pumps
   - in yachts of less than 1000 GT: at least 2 power-driven pumps, one of which is to be independently driven.

b) This may be achieved:
   - either with minimum 2 main fire pumps, as per [2.3.3], or
   - with minimum 1 main fire pump and 1 emergency fire pump, as per [2.3.4].

2.3.3 Arrangement with minimum two main fire pumps

a) The two main fire pumps and the fuel supply or source of power for each pump are to be situated within compartments separated at least by an A-0 class division, so that a fire in any one compartment will not render both fire pumps inoperable. The steel compartment in which one main fire pump is located should not have more than one bulkhead and/or deck adjacent to the compartment containing the other main fire pump.

b) Total capacity of required fire pumps, at the pressure specified in [2.2.6]:

   The quantity of water is not to be less than four thirds of the quantity required in Ch 1, Sec 5, [4.3.2], item b) to be dealt with by each of the independent bilge pumps, provided that in no ship need the total required capacity of the fire pumps exceed 180 m^3/hour.

c) Capacity of each fire pump

   Each of the required fire pumps is to have a capacity not less than 40% of the total required capacity, but in any case not less than 25 m^3/hour, and each such pump is to be capable in any event of delivering at least the two required jets of water. These fire pumps are to be capable of supplying the fire main system under the required conditions. Where more pumps than the minimum of required pumps are installed, such additional pumps are to have a capacity of at least 25 m^3/h and are to be capable of delivering at least the two jets of water required in [2.2.5].

2.3.4 Arrangement with minimum one main fire pump and one emergency fire pump

a) If a fire in any one compartment could put all the pumps out of action, there is to be an alternative means consisting of a fixed independently driven power-operated emergency fire pump. Its source of power and sea connection should be located outside the space where the main fire pump is located.

b) Capacity of the main fire pump(s), at the pressure specified in [2.2.6]:

   The total capacity of the main fire pump(s) (excluding the emergency fire pump) and the capacity of each main fire pump are to comply with [2.3.3], items b) and c).

c) Capacity of the emergency fire pump, at the pressure specified in [2.2.6]:

   The emergency fire pump is to have a capacity not less than 40% of the total capacity required in item b) of [2.3.3], but in any case not less than 15 m^3/hour. The emergency fire pump is to be capable of supplying two jets of water to the satisfaction of the society and the amount of water needed for any fixed fire-extinguishing system provided to protect the space where the main fire pumps are located.

d) Requirements for the space containing the emergency fire pump

   1) Location of the space

      The space containing the fire pump is not to be contiguous to the boundaries of machinery spaces of category A or those spaces containing main fire pumps. Where this is not practicable, the common bulkhead between the two spaces is to be insulated to a standard of structural fire protection equivalent to that required for a control station in Ch 4, Sec 7, [2.1.4].

   2) Access to the emergency fire pump

      No direct access is to be permitted between the machinery space and the space containing the emergency fire pump and its source of power. When this is impracticable, the Society may accept an arrangement where the access is by means of an air-lock with the door of the machinery space being of A-60 class standard and the other door being at least steel, both reasonably gastight, self-closing and without any hold-back arrangements. Alternatively, the access may be through a watertight door capable of being operated from a space remote from the machinery space and the space containing the emergency fire pump and unlikely to be cut off in the event of fire in those spaces. In such cases, a second means of access to the space containing the emergency fire pump and its source of power is to be provided.

      When a single access to the emergency fire pump room is through another space adjoining a machinery space of category A or the spaces containing the main fire pumps, an A-60 class boundary is required between such other space and the machinery space of category A or the spaces containing the main fire pumps.

3) Ventilation of the emergency fire pump space

Ventilation arrangements to the space containing the independent source of power for the emergency fire pump are to be such as to preclude, as far as practicable, the possibility of smoke from a machinery space fire entering or being drawn into that space.

If the space is mechanically ventilated the power is to be supplied by the emergency source.

4) Illumination of the space

The room where the emergency fire pump prime mover is located is to be illuminated from the emergency source of supply and is to be well ventilated.

e) Suction heads, sea suction, diesel engines, fuel tanks, prime mover and source of power of the emergency fire pump are to comply with NR467 Rules for Steel Ships, Pt C, Ch 4, Sec 13, [11].

2.3.5 When the main water supply for other fixed fire-extinguishing systems is from the fire pumps, the total capacity of the fire pumps is to be sufficient for the simultaneous use of:

- the minimum required number of jets of water at the required pressure from the fire main, and
- other fixed fire-extinguishing systems primarily fed by the fire main at their required output, or likely combination thereof.

2.4 Fire hoses and nozzles

2.4.1 General specifications

a) Fire hoses are to be of non-perishable material approved by the Society and are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Each hose is to be provided with a nozzle and the necessary couplings. Hoses specified in this Section as "fire hoses" are to, together with any necessary fittings and tools, be kept ready for use in conspicuous positions near the water service hydrants or connections. Fire hoses are to have a length of at least 10 m, but not more than:
   - 15 m in machinery spaces
   - 20 m in other spaces and open decks, and
   - 25 m for open decks on yachts with a maximum breadth in excess of 30 m.

b) Unless one hose and nozzle is provided for each hydrant in the ship, there is to be complete interchangeability of hose couplings and nozzles.

2.4.2 Number and diameter of fire hoses

a) Yachts are to be provided with fire hoses, the number and diameter of which are to be to the satisfaction of the Society.

b) In yachts:

1) of 1000 GT and upwards, the number of fire hoses to be provided is to be one for each 30 m length of the ship and one spare, but in no case less than five in all. This number does not include any hoses required in any engine-room or boiler room. The Society may increase the number of hoses required so as to ensure that hoses in sufficient number are available and accessible at all times, having regard to the type of ship and the nature of trade in which the ship is employed.

Hydrants in machinery spaces of category A are to be provided with fire hoses, and

2) of less than 1000 GT, the number of fire hoses to be provided is to be calculated in accordance with the provisions of item 1) above. However the number of hoses is to be in no case less than three.

2.4.3 Size and type of nozzles

a) For the purposes of this Section, standard nozzle sizes are to be 12 mm, 16 mm and 19 mm or as near thereto as possible. Larger diameter nozzles may be permitted at the discretion of the Society.

b) For accommodation and service spaces, a nozzle size greater than 12 mm need not be used.

c) For machinery spaces and exterior locations, the nozzle size is to be such as to obtain the maximum discharge possible from two jets at the pressure mentioned in [2.2.6] from the smallest pump, provided that a nozzle size greater than 19 mm need not be used.

d) Nozzles are to be of an approved dual-purpose type (i.e. spray/jet type) incorporating a shut-off.

3 Portable fire extinguishers

3.1 Type and design

3.1.1 Portable fire extinguishers are to comply with the requirements of Ch 4, Sec 13, [2].

3.2 Arrangement of fire extinguishers

3.2.1 The number and the type of portable fire extinguishers required for accommodation spaces, service spaces and control stations are to be as follows:

- in accommodation spaces of yachts of 1000 gross tonnage and upwards: at least five foam extinguishers or equivalent, but not less than one for each 'tweendeck
- in accommodation spaces of yachts of less than 1000 gross tonnage: at least two foam extinguishers or equivalent, but not less than one for each 'tweendeck
- in the proximity of any electric switchboard or section board having a power of 20 kW and upwards: at least one carbon dioxide or powder extinguisher
- in any service space where deep fat cooking equipment is installed: at least one foam extinguisher or equivalent
- in the proximity of any paint or flammable product locker: at least one foam extinguisher or equivalent
- on the navigating bridge: one carbon dioxide extinguisher or equivalent.

Note 1: Portable fire extinguishers of the carbon dioxide type are not to be located or provided for use in accommodation spaces, except for use at the wheelhouse.

3.2.2 One of the portable fire extinguishers intended for use in any space is to be stowed near the entrance to that space.

4 Fixed fire-extinguishing systems

4.1 Types of fixed fire-extinguishing systems

4.1.1 A fixed fire-extinguishing system required by Article [5] may be any of the following systems:

a) a fixed gas fire-extinguishing system complying with the provisions of Ch 4, Sec 13, [3]

b) a fixed pressure water-spraying fire-extinguishing system complying with the provisions of Ch 4, Sec 13, [4].

4.1.2 Where a fixed fire-extinguishing system not required by this Section is installed, it has to meet the relevant requirements of this Section.

4.1.3 Fire-extinguishing systems using Halon 1211, 1301, and 2402 and perfluorocarbons are to be prohibited.

4.2 Closing appliances for fixed gas fire-extinguishing systems

4.2.1 Where a fixed gas fire-extinguishing system is used, openings which may admit air to, or allow gas to escape from, a protected space are to be capable of being closed from outside the protected space.

4.3 Water pumps for other fire-extinguishing systems

4.3.1 Pumps, other than those serving the fire main, required for the provision of water for fire-extinguishing systems required by the present Section, their sources of power and their controls are to be installed outside the space or spaces protected by such systems and are to be so arranged that a fire in the space or spaces protected will not put any such system out of action.

5 Fire-extinguishing arrangements in machinery spaces

5.1 General

5.1.1 The fire-extinguishing arrangements in machinery spaces of category A are detailed in Article [5], depending on contained machinery types. Reference is also made to Tab 2.

5.2 Machinery spaces containing oil-fired boilers or oil fuel units

5.2.1 Fixed fire-extinguishing systems

Machinery spaces of category A containing oil fired boilers or oil fuel units are to be provided with any one of the fixed fire-extinguishing systems in [4.1].

In each case, if the engine-room and boiler room are not entirely separate, or if fuel oil can drain from the boiler room into the engine-room, the combined engine and boiler rooms is to be considered as one compartment.

Table 2 : Number of systems, appliances and extinguishers required in machinery spaces of category A

Equipment contained in concerned machinery space of category A	Fixed fire-extinguishing system	Portable foam applicator	Portable foam extinguishers or equivalent	135 l wheeled foam extinguisher	45 l wheeled foam extinguisher	Sand box
Internal combustion machinery only, or Internal combustion machinery and oil fuel units	1	1	sufficient number, within 10 m walking distance from any point (minimum 2)	–	sufficient number to be directed to any fire hazard (typically 1 per level) **(1)**	–
Oil-fired boilers only, or Oil-fired boilers and oil fuel units	1	1	2	1 **(2)**	–	1
Oil fuel units only	1	–	2	–	–	–
Incinerator	1	–	2 **(3)**	–	–	–
Internal combustion machinery and oil-fired boiler, or Internal combustion machinery, oil-fired boiler, and oil fuel units	1	1	sufficient number, within 10 m walking distance from any point (minimum 2)	1 **(2)**	sufficient number to be directed to any fire hazard (typically 1 per level) **(1)** **(4)**	1

(1) May be replaced by one additional portable foam applicator.
(2) Not required for such spaces wherein all boilers contained therein are for domestic services and are less than 175 kW.
(3) May be replaced by one portable foam applicator.
(4) One 45 l wheeled foam extinguisher maybe replaced by the 135 l wheeled foam extinguisher.

5.2.2 Additional fire-extinguishing arrangements

a) There is to be in each boiler room or at an entrance outside of the boiler room at least one portable foam applicator unit complying with the provisions of Ch 4, Sec 13, [2].

b) There are to be at least two portable foam extinguishers or equivalent in each firing space in each boiler room and in each space in which a part of the oil fuel installation is situated. There is to be not less than one approved foam-type extinguisher of at least 135 l capacity or equivalent in each boiler room. These extinguishers are to be provided with hoses on reels suitable for reaching any part of the boiler room. In the case of domestic boilers of less than 175 kW an approved foam-type extinguisher of at least 135 l capacity is not required.

   In the case of domestic boilers of less than 175 kW in yachts, the Society may consider relaxing the requirements of this item b) to the provision of two portable fire extinguishers.

   In the proximity of any electric switchboard or section board having a power of 20 kW and upwards at least one CO_2 or powder extinguisher is to be fitted.

c) In each firing space there is to be a receptacle containing at least 0,1 m^3 sand, sawdust impregnated with soda, or other approved dry material, along with a suitable shovel for spreading the material. An approved portable extinguisher may be substituted as an alternative.

5.3 Machinery spaces containing internal combustion machinery

5.3.1 Fixed fire-extinguishing systems

Machinery spaces of category A containing internal combustion machinery are to be provided with one of the fixed fire-extinguishing systems required in [4.1].

5.3.2 Additional fire-extinguishing arrangements

a) There is to be at least one portable foam applicator unit complying with the provisions of Ch 4, Sec 13, [2].

b) There is to be in each such space approved foam-type fire extinguishers, each of at least 45 l capacity or equivalent, sufficient in number to enable foam or its equivalent to be directed onto any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards. In addition, there is to be provided a sufficient number of portable foam extinguishers or equivalent which are to be so located that no point in the space is more than 10 m walking distance from an extinguisher and that there are at least two such extinguishers in each such space. For smaller spaces of yachts, the Society may consider relaxing this requirement.

c) In the case of machinery spaces containing both boilers and internal combustion engines, [5.2] and [5.3] apply, with the exception that one of the foam fire extinguishers of at least 45 l capacity or equivalent may be omitted provided that the 135 l extinguisher can efficiently and readily protect the area covered by the 45 l extinguishers.

d) There is to be at least one CO_2 or powder extinguisher in the proximity of any electric switchboard or section board having a power of 20 kW and upwards.

6 Fire-extinguishing arrangements in control stations, accommodation and service spaces

6.1 Sprinkler and water spray systems

6.1.1 When a fixed smoke detection and fire alarm system complying with the provisions of Ch 4, Sec 13, [5] is provided only in corridors, stairways and escape routes within accommodation spaces, an automatic sprinkler system is to be installed in accordance with Ch 4, Sec 3, [5.2.1], item b).

6.2 Spaces containing flammable liquid

6.2.1 Paint lockers are to be protected by:

a) a carbon dioxide system, designed to give a minimum volume of free gas equal to 40% of the gross volume of the protected space

b) a dry powder system, designed for at least 0,5 kg powder/m^3

c) a water spraying or sprinkler system, designed for 5 l/m^2 min. Water spraying systems may be connected to the fire main of the yacht, or

d) a system providing equivalent protection, as determined by the Society.

In all cases, the system is to be operable from outside the protected space.

6.2.2 Flammable liquid lockers are to be protected by an appropriate fire-extinguishing arrangement approved by the Society.

6.2.3 For lockers of a deck area of less than 4 m^2, which do not give access to accommodation spaces, a portable carbon dioxide fire extinguisher sized to provide a minimum volume of free gas equal to 40% of the gross volume of the space may be accepted in lieu of a fixed system. A discharge port is to be arranged in the locker to allow the discharge of the extinguisher without having to enter into the protected space. The required portable fire extinguisher is to be stowed adjacent to the port. Alternatively, a port or hose connection may be provided to facilitate the use of fire main water.

6.3 Deep-fat cooking equipment

6.3.1 Deep-fat cooking equipment is to be fitted with the following:

a) an automatic or manual fire-extinguishing system tested to an international standard

b) a primary and backup thermostat with an alarm to alert the operator in the event of failure of either thermostat

c) arrangements for automatically shutting off the electrical power upon activation of the fire-extinguishing system

d) an alarm for indicating operation of the fire-extinguishing system in the galley where the equipment is installed, and

e) controls for manual operation of the fire-extinguishing system which are clearly labelled for ready use by the crew.

Section 9 Escape for Yachts of 500 GT and over

1 General

1.1 Application

1.1.1 The present Section applies only to yachts of 500 GT and over.

2 Means of escape

2.1 General requirements

2.1.1 Unless expressly provided otherwise in this Article, at least two widely separated and ready means of escape are to be provided from all spaces or groups of spaces.

2.1.2 Lifts are not to be considered as forming one of the means of escape as required by this Article.

2.1.3 The securing devices of hatches are to be of type which can be opened from both sides.

2.2 Means of escape from control stations, accommodation spaces and service spaces

2.2.1 General requirements

a) Stairways and ladders are to be so arranged as to provide ready means of escape to the lifeboat and liferaft embarkation deck from passenger and crew accommodation spaces and from spaces in which the crew is normally employed, other than machinery spaces.

b) Unless expressly provided otherwise in this Article, a corridor, lobby, or part of a corridor from which there is only one route of escape is to be prohibited. Dead-end corridors used in service areas which are necessary for the practical utility of the yacht, such as fuel oil stations and athwartship supply corridors, are to be permitted, provided such dead-end corridors are separated from crew accommodation areas and are inaccessible from passenger accommodation areas. Also, a part of a corridor that has a depth not exceeding its width is considered a recess or local extension and is permitted.

c) Doors in escape routes are, in general, to open in way of the direction of escape, except that:

   1) individual cabin doors may open into the cabins in order to avoid injury to persons in the corridor when the door is opened, and

   2) doors in vertical emergency escape trunks may open out of the trunk in order to permit the trunk to be used both for escape and for access.

2.2.2 Escape from spaces below the bulkhead deck

Below the bulkhead deck, two means of escape, at least one of which is to be independent of watertight doors, is to be provided from each watertight compartment or similarly restricted space or group of spaces. Exceptionally, the Society may dispense with one of the means of escape for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors and does not pass through a galley or a machinery space.

2.2.3 Escape from spaces above the bulkhead deck

Above the bulkhead deck there is to be at least two means of escape from each main vertical zone or similarly restricted space or group of spaces.

2.2.4 Details of means of escape

a) At least one of the means of escape required by [2.2.2] and [2.2.3] is to consist of a readily accessible escape way, consisting in a succession of corridors and/or stairways, from the level of its origin to the embarkation area or to the open deck. It should be possible to reach the embarkation area from any cabin, by passing only through corridors and stairways.

b) The means of escape from any accommodation space or from any normally occupied service space are to be arranged so that it is possible to reach the open deck without passing through a galley or a machinery space of category A or other space with a high fire risk, such as a vehicle space.

c) Stairways serving only a space and a balcony in that space are not to be considered as forming one of the required means of escape.

d) Each level within an atrium has to have two means of escape, one of which is to give direct access to an enclosed vertical means of escape meeting the requirements of a) above. The same requirement applies in general to public spaces spanning two decks.

2.2.5 Normally locked doors that form part of an escape route

Cabin doors are not to require keys to unlock them from inside the room. No doors along any designated escape route should require keys to unlock them when moving in the direction of escape.

2.3 Means of escape from machinery spaces

2.3.1 Escape from machinery spaces below the bulkhead deck

Where the machinery space is below the bulkhead deck, the two means of escape are to consist of either:

a) two sets of steel ladders as widely separated as possible, leading to doors in the upper part of the space, similarly separated and from which access is provided to the appropriate lifeboat and liferaft embarkation decks. One of these ladders is to be located within a protected enclosure that satisfies Ch 4, Sec 7, [2.1.4], category (4), from the lower part of the space it serves to a safe position outside the space. Self-closing fire doors of the same fire integrity standards are to be fitted in the enclosure. The ladder is to be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The protected enclosure is to have minimum internal dimensions of at least 800 mm x 800 mm, and is to have emergency lighting provisions. For escape routes from the machinery spaces of category A, the hatch should also have minimum internal dimensions of 800 mm x 800 mm.

b) one steel ladder leading to a door in the upper part of the space from which access is provided to the embarkation deck and additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the embarkation deck.

2.3.2 Escape from machinery spaces above the bulkhead deck

Where the space is above the bulkhead deck, the two means of escape are to be as widely separated as possible and the doors leading from such means of escape are to be in a position from which access is provided to the appropriate lifeboat and liferaft embarkation decks. Where such means of escape require the use of ladders, these is to be of steel.

2.3.3 Dispensation from two means of escape

In a yacht of less than 1000 GT, the Society may dispense with one of the means of escape, due regard being paid to the width and disposition of the upper part of the space.

In a yacht of 1000 GT and above, the Society may dispense with one means of escape from any such space, including a normally unattended auxiliary machinery space, so long as either a door or a steel ladder provides a safe escape route to the embarkation deck, due regard being paid to the nature and location of the space and whether persons are normally employed in that space. In the steering gear space, a second means of escape is to be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

2.3.4 Escape from machinery control rooms

Two means of escape are to be provided from a machinery control room located within a machinery space, at least one of which leading to a safe position outside the machinery space.

2.4 Means of escape from vehicle spaces

2.4.1 At least two means of escape are to be provided in vehicle spaces. The escape routes are to provide a safe escape to the embarkation area.

Section 10 Fire Control Plans

1 General

1.1 Application

1.1.1 The present Section applies to all yachts.

2 Yachts of less than 24 m in length

2.1 Safety instructions

2.1.1 Instructions concerning the maintenance and operation of all the equipment and installations on board for the fighting and containment of fire are to be kept under one cover, readily available in an accessible position.

3 Yachts of 24 m in length and over

3.1 Compilation of the fire control plans

3.1.1 General arrangement plans are to be permanently exhibited for the guidance of the Master and crew of the yacht. The content of the plan(s) is to adequately show and describe the principal fire prevention and protection equipment and materials. As far as practical, symbols used on the plans are to comply with a recognised international standard.

3.1.2 For each deck, the plan(s) should show the position of control stations, the various fire sections enclosed by A class divisions, the sections enclosed by B class divisions together with particulars of the fire detection and fire alarm systems, means of access to different compartments, decks, etc. and the ventilating system, locations and means of control of systems and openings which are to be closed down in a fire emergency, position of fuel oil valve remote control and fuel oil pump stops. The sprinkler installation, if any, and the fixed and portable fire-extinguishing appliances are also to be indicated.

3.1.3 For yachts of 500 GT and over, indications of the ventilating system should also include particulars of the fan control positions, the position of dampers and identification numbers of the ventilating fans serving each section.

3.1.4 Alternatively, at the discretion of the Society, the afore mentioned details of [3.1.2] and [3.1.3] may be set out in a booklet, a copy of which is to be supplied to each officer, and one copy is at all times to be available on board in an accessible position.

3.1.5 Plans and booklets are to be kept up to date; any alterations thereto are to be recorded as soon as practicable. Description in such plans and booklets is to be in the language or languages required by the Society. If the language is neither English nor French, a translation into one of those languages is to be included.

3.1.6 In addition, instructions concerning the maintenance and operation of all the equipment and installations on board for the fighting and containment of fire are to be kept under one cover, readily available in an accessible position.

Section 11 Helicopter Facilities

1 General

1.1 Application

1.1.1 In addition to complying with the requirements of the other sections of this Chapter, as appropriate, all yachts equipped with helicopter facilities are to comply with those of this Section.

1.1.2 Items e) and f) of [3.1.1] and Articles [5] and [6] do not contain requirements applicable for the purpose of classification. They are reproduced for reference purposes only.

1.2 Contents

1.2.1 This Section refers to IMO Resolution A.855(20) dated 27 November 1997.

1.3 Definitions

1.3.1 Helideck

Helideck is a purpose-built helicopter landing area located on a yacht including all structure, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

1.3.2 Helicopter facilities

Helicopter facility is a helideck including any refuelling and hangar facilities.

2 Structure

2.1 Construction of steel or other equivalent materials

2.1.1 In general, the construction of the helidecks is to be of steel or other equivalent materials. If the helideck forms the deckhead of enclosed spaces, it is to be insulated to:

- A-60 class standard for yachts of 500 GT and over
- for yachts of less than 500 GT: at least the same standard as used for machinery spaces of category A boundaries, as required in Ch 4, Sec 2, [3.2.1].

2.2 Construction of materials other than steel

2.2.1 Construction of aluminium or other low melting points metals

If the Society permits aluminium or other low melting point metal construction that is not made equivalent to steel and if the helideck forms the deckhead of enclosed spaces, the following conditions are to be satisfied:

a) enclosed spaces under the platform are to have no opening in bulkheads or in deckhead within the helicopter landing area (defined by the aiming circle marking surrounding the ‘H’)

b) windows under the platform are to be provided with steel shutters.

2.2.2 Construction of composite materials

If the platform is made of composite materials and if the helideck forms the deckhead of enclosed spaces, approval is subject to special consideration of the society and the following conditions are at least to be satisfied:

a) the platform is to be fire insulated on the top so as to be made equivalent to steel, with equivalent fire resistance properties as required in [2.1.1]

b) enclosed spaces under the platform are to have no opening in bulkheads or in deckhead within the helicopter landing area (defined by the aiming circle marking surrounding the ‘H’)

c) windows under the platform are to be provided with steel shutters.

2.3 Means of escape

2.3.1 A helideck is to be provided with both a main and an emergency means of escape and access for fire-fighting and rescue personnel. These are to be located as far apart from each other as is practicable and preferably on opposite sides of the helideck.

3 Fire-fighting appliances

3.1 General

3.1.1 In close proximity to the helideck, the following fire-fighting appliances are to be provided and stored near the means of access to that helideck:

a) at least two dry powder extinguishers having a total capacity of not less than 45 kg

b) carbon dioxide extinguishers of a total capacity of not less than 18 kg or equivalent

c) a suitable foam application system consisting of monitors or foam-making branch pipes capable of delivering foam to all parts of the helideck in all weather conditions in which helicopters can operate. The system is to be capable of delivering a discharge rate as required in Tab 1 for at least five minutes

d) the principal agent is to meet the applicable performance standards of the International Civil Aviation Organization - Airport Services Manual, Part 1 - Rescue and Firefighting, Chapter 8 - Extinguishing Agent Characteristics, Paragraph 8.1.5 - Foam Specifications Table 8-1, Level "B" foam, and be suitable for use with salt water

e) at least two nozzles of an approved dual-purpose type (jet/spray) and hoses sufficient to reach any part of the helideck

f) two sets of fire-fighter's outfits, and

g) at least the following equipment, stored in a manner that provides for immediate use and protection from the elements:

- adjustable wrench
- blanket, fire-resistant
- cutters, bolt 60 cm
- hook, grab or salving
- hacksaw, heavy duty complete with 6 spare blades
- ladder
- lift line 5 mm diameter and 15 m in length
- pliers, side-cutting
- set of assorted screwdrivers, and
- harness knife complete with sheath.

Table 1 : Foam discharge rates

Category	Helicopter overall length	Discharge rate foam solution (l/min)
H1	< 15 m	250
H2	≥ 15 m and < 24 m	500
H3	≥ 24 m and < 35 m	800

3.2 Drainage facilities

3.2.1 Drainage facilities in way of helidecks are to be constructed of steel and are to lead directly overboard independent of any other system and are to be designed so that drainage does not fall onto any part of the yacht.

4 Helicopter fuel system and refuelling facilities

4.1 General

4.1.1 Helicopter fuel systems and refuelling facilities are to comply with the requirements of NR467, Pt C, Ch 4, Sec 11.

4.2 Arrangement of spaces containing the refuelling installations

4.2.1 Ventilation

Enclosed hangar facilities or enclosed spaces containing refuelling installations are to be provided with mechanical ventilation as required by Ch 4, Sec 12, [2] for enclosed vehicle spaces. Ventilation fans are to be of non-sparking type (see Ch 4, Sec 12, [1.2.5]).

4.2.2 Electric equipment and wiring

Electric equipment and wiring in enclosed hangars or enclosed spaces containing refuelling installations are to comply with the requirements of Ch 4, Sec 12, [3].

5 Occasional and emergency helicopter operations

5.1 General

5.1.1 Where helicopters land or conduct winching operations on an occasional or emergency basis on yachts without helidecks, fire-fighting equipment fitted in accordance with the requirements of:

- Ch 4, Sec 5, [2] for yachts of less than 500 GT, and
- Pt C, Ch 4, Sec 6, [1] of NR467 Rules for Steel Ships for yachts of 500 GT and over,

may be used.

This equipment is to be made readily available in close proximity to the landing or winching areas during helicopter operations.

6 Operations manual

6.1 General

6.1.1 Each helicopter facility is to have an operations manual, including a description and a checklist of safety precautions, procedures and equipment requirements. This manual may be part of the yacht's emergency response procedures.

Section 12 Protection of Vehicle Spaces

1 General requirements and application

1.1 Application

1.1.1 In addition to complying with the requirements of the other sections of this Chapter, as appropriate, all yachts having vehicle spaces on board are to comply with those of this Section.

1.2 Definitions

1.2.1 Vehicle spaces

Vehicle spaces are those spaces containing vehicles or crafts with fuel in their tanks for their own propulsion.

1.2.2 Open vehicle spaces

Open vehicle spaces are the vehicle spaces which are either open at both ends or have an opening at one end and are provided with adequate natural ventilation effective over their entire length through permanent openings distributed in the side plating or deckhead or from above, having a total area of at least 10% of the total area of the space sides.

1.2.3 Enclosed vehicle spaces

Enclosed vehicle spaces are the vehicle spaces which are neither open vehicle spaces nor weather decks.

1.2.4 Weather decks

Weather deck is a deck which is completely exposed to the weather from above and from at least two sides.

1.2.5 Non-sparking fan

A fan is considered as non-sparking if in either normal or abnormal conditions it is unlikely to produce sparks. For this purpose, the following criteria are to be met:

a) Design criteria:
   1) The air gap between the impeller and the casing is to be not less than 1/10 of the shaft diameter in way of the impeller bearing and in any case not less than 2 mm, but need not exceed 13 mm.
   2) Protective screens with square mesh of not more than 13 mm are to be fitted to the inlet and outlet of ventilation ducts to prevent objects entering the fan housing.

b) Materials:
   1) The impeller and the housing in way of the impeller are to be made of spark-proof materials which are recognised as such by means of an appropriate test to the satisfaction of the Society.
   2) Electrostatic charges, both in the rotating body and the casing, are to be prevented by the use of antistatic materials. Furthermore, the installation on board of ventilation units is to be such as to ensure their safe bonding to the hull.
   3) Tests may not be required for fans having the following material combinations:
      - impellers and/or housings of non-metallic material, due regard being paid to the elimination of static electricity
      - impellers and housings of non-ferrous materials
      - impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous material is fitted in way of the impeller
      - any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm design tip clearance.
   4) The following impeller and housing combinations are considered as sparking and therefore are not permitted:
      - impellers of an aluminium alloy or a magnesium alloy and a ferrous housing, regardless of tip clearance
      - housings made of an aluminium alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance
      - any combination of ferrous impeller and housing with less than 13 mm design tip clearance.
   5) Complete fans are to be type-tested in accordance with either the Society’s requirements or national or international standards accepted by the Society.

2 Ventilation

2.1 Application

2.1.1 This Article is only applicable to enclosed vehicle spaces.

2.1.2 Power ventilation complying with sub-articles [2.2] to [2.5] is to be provided.

2.1.3 Alternatively, on board yachts less than 500 GT, natural ventilation only may be provided, if the vehicle space has a direct access on the open deck and if a suitable gas detection system is provided, with audible and visual alarm in the wheelhouse and in the crew mess. In this case, sub-articles [2.2] to [2.4] are not applicable, but sub-article [2.5] remains applicable.

2.2 Capacity of ventilation systems

2.2.1 There is to be provided an effective power ventilation system sufficient to give at least 6 air changes per hour (based on the empty space).

2.3 Performance of ventilation systems

2.3.1 The power ventilation system required in [2.2.1] is to be separate from other ventilation systems. The system is to be capable of being controlled from a position outside such spaces.

2.3.2 The ventilation system is to be such as to prevent air stratification and the formation of air pockets.

2.3.3 Where the flash point of the fuel is less than 60°C, fans are to be of non-sparking type.

2.4 Indication of ventilation systems

2.4.1 Means is to be provided on the navigation bridge to indicate any loss of the required ventilating capacity.

2.5 Closing appliances and ducts

2.5.1 Arrangements are to be provided to permit a rapid shut-down and effective closure of the ventilation system from outside of the space in case of fire, taking into account the weather and sea conditions.

3 Electrical equipment

3.1 Application

3.1.1 This Article is applicable to open and enclosed vehicle spaces.

3.2 Protection of electrical equipment

3.2.1 For the protection of electrical equipment, refer to Ch 2, Sec 2, [8].

4 Detection and alarm

4.1 Application

4.1.1 This Article is applicable to open and enclosed vehicle spaces.

4.2 Fixed fire detection and alarm system

4.2.1 A fixed fire detection and fire alarm system complying with the requirements of Ch 4, Sec 13, [6] are to be so installed and arranged as to provide smoke detection.

5 Fire extinction

5.1 Application

5.1.1 Open and enclosed vehicle spaces of 10 m^2 and over in area are to be fitted with a fixed fire-extinguishing system, which may be either:

a) a fixed water spray system, complying with the provisions of [5.2], or

b) an equivalent fixed water mist system, complying with the provisions of Ch 4, Sec 13, [4.2.2].

5.2 Fixed water spray system

5.2.1 If a water spray system is installed, it has to have a coverage of 3,5 l/m^2/minute over the total area of deck and may be taken from the fire main with the isolating valve located outside the vehicle space. Adequate provision is to be made for drainage of water introduced to the space.

5.2.2 The water spray system is to be in compliance with Ch 4, Sec 13, [4.1.2].

Section 13 Fire Safety Systems

1 General

1.1 Application

1.1.1 This Section is applicable to fire safety systems as referred to in Ch 4, Sec 2 to Ch 4, Sec 12.

1.2 Use of toxic extinguishing media

1.2.1 The use of a fire-extinguishing medium which, in the opinion of the Society, either by itself or under expected conditions of use gives off toxic gases, liquids and other substances in such quantities as to endanger persons is not to be permitted.

2 Fire extinguishers

2.1 Portable fire extinguishers

2.1.1 Safety requirements

Fire extinguishers containing an extinguishing medium which, in the opinion of the Society, either by itself or under the expected conditions of use gives off toxic gases in such quantities as to endanger persons or which is an ozone depleting substance is not to be permitted.

2.1.2 Quantity of medium

a) Each powder or carbon dioxide extinguisher is to have a capacity of at least 5 kg and each foam extinguisher is to have a capacity of at least 6 l. The mass of all portable fire extinguishers is not to exceed 23 kg and they are to have a fire-extinguishing capability at least equivalent to that of a 6 l fluid extinguisher.

b) The Society is to determine the equivalents of fire extinguishers.

2.2 Portable foam applicators

2.2.1 If required by Ch 4, Sec 8, [5], a portable foam applicator unit consists of a foam nozzle of an inductor type capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 l of foam-forming liquid and one spare tank of foam making liquid. The nozzle is to be capable of producing effective foam suitable for extinguishing an oil fire, at the rate of at least 1,5 m^3/min.

3 Fixed gas fire-extinguishing systems

3.1 General

3.1.1 Application

Yachts on which a fixed gas fire-extinguishing system is installed are to comply with requirements [3.1.2] to [3.1.4].

3.1.2 Engineering specifications

a) Fire-extinguishing medium

   1) Where the quantity of the fire-extinguishing medium is required to protect more than one space, the quantity of medium available need not be more than the largest quantity required for any one space so protected.

   2) Where the volume of free air contained in air receivers in any space is such that, if released in such space in the event of fire, such release of air within that space would seriously affect the efficiency of the fixed fire-extinguishing system, the Society require the provision of an additional quantity of fire-extinguishing medium.

      The volume of starting air receivers, converted to free air volume, is to be added to the gross volume of the machinery space when calculating the necessary quantity of the fire-extinguishing medium. Alternatively, a discharge pipe from the safety valves may be fitted and led directly to the open air.

   3) Means are to be provided for the crew to safely check the quantity of the fire-extinguishing medium in the containers.

   4) Containers for the storage of fire-extinguishing medium and associated pressure components are to be designed to pressure codes of practice to the satisfaction of the Society having regard to their locations and maximum ambient temperatures expected in service.

b) Installation requirements

1) The piping for the distribution of fire-extinguishing medium is to be arranged and discharge nozzles so positioned that a uniform distribution of the medium is obtained.

   In machinery spaces, the discharge nozzles are to be positioned in the upper and lower parts of these spaces.

2) Except as otherwise permitted by the Society, pressure containers required for the storage of the fire-extinguishing medium, other than steam, are to be located outside the protected spaces in accordance with [3.1.4].

3) The storage of the fire extinguishing medium is not permitted within spaces which may contain air/flammable gas mixtures.

c) System control requirements

1) The necessary pipes for conveying fire-extinguishing medium into the protected spaces are to be provided with control valves so marked as to indicate clearly the space to which the pipes are led. Suitable provision is to be made to prevent inadvertent release of the medium into the space. The pipes may pass through accommodation areas provided that they are of substantial thickness and that their tightness is verified with a pressure test, after their installation, at a pressure head not less than 5 N/mm^2. In addition, pipes passing through accommodation areas are to be joined only by welding and are to not be fitted with drains or other openings within such spaces. The pipes are not to pass through refrigerated spaces.

   Control valves are to be capable of local operation.

   The open or closed position of control valves is to be indicated.

   Means are to be provided in order to permit the blowing through each branch line of the piping system downstream of the master (control) valves.

2) Means are to be provided for automatically giving audible warning of the release of fire-extinguishing medium into any spaces in which personnel normally work or to which they have access. The pre-discharge alarm is to be automatically activated (e.g. by opening of the release cabinet door). The alarm is to operate for the length of time needed to evacuate the space, but in no case less than 20 seconds before the medium is released.

3) The means of control of any fixed gas fire-extinguishing system are to be readily accessible, simple to operate and are to be grouped together in as few locations as possible at positions not likely to be cut off by a fire in a protected space. At each location there is to be clear instructions relating to the operation of the system having regard to the safety of personnel.

4) Automatic release of fire-extinguishing medium should generally not be allowed, except for yachts of less than 24 m in length if conditions of Ch 4, Sec 5, [3.1.3], item a) are fulfilled.

3.1.3 Gas-tightness of the protected space

Every space protected by a fixed gas fire-extinguishing system is to be designed such that rapid and efficient gas-tightness can be ensured. The means of closing may be manually operated. Fans serving the protected spaces are to be capable of being stopped from outside the protected spaces.

3.1.4 Storage rooms of fire-extinguishing medium

When the fire-extinguishing medium is stored outside a protected space, it is to be stored in a room which is located behind the forward collision bulkhead, and is used for no other purposes. Any entrance to such a storage room is to be preferably from the open deck and is to be independent of the protected space. Spaces which are located below deck or spaces where access from the open deck is not provided is to be fitted with a mechanical ventilation system designed to take exhaust air from the bottom of the space and is to be sized to provide at least 6 air changes per hour. Access doors are to open outwards, and bulkheads and decks, including doors and other means of closing any opening therein, which form the boundaries between such rooms and adjacent enclosed spaces, are to be gastight. On board yachts of 500 GT and over, storage rooms have to be considered as fire control stations.

3.2 Carbon dioxide systems

3.2.1 Application

In addition to [3.1], fixed carbon dioxide systems are to comply with [3.2.2] and [3.2.3].

3.2.2 General arrangement

a) Quantity of fire-extinguishing medium

1) The quantity of carbon dioxide carried is to be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either:

   - 40% of the gross volume of the largest machinery space so protected, the volume to exclude that part of the casing above the level at which the horizontal area of the casing is 40% or less of the horizontal area of the space concerned taken midway between the tank top and the lowest part of the casing, or

- 35% of the gross volume of the largest machinery space protected, including the casing.

  In the calculation of 35% of the above-mentioned volume, the net volume of the funnel is to be considered up to a height equal to the whole casing height if the funnel space is in open connection with the machinery space without inter-position of closing means.

2) The percentages specified in item 1) above may be reduced to 35% and 30%, respectively, for yachts of less than 2000 GT provided that, where two or more machinery spaces are not entirely separate, they are to be considered as forming one space.
3) For the purpose of items a)1) and a)2), the volume of free carbon dioxide is to be calculated at 0,56 m^3/kg.
4) For machinery spaces, the fixed piping system is to be such that 85% of the gas can be discharged into the space within 2 minutes.

b) Controls

1) Carbon dioxide systems are to comply with the following requirements:
   - two separate controls shall be provided for releasing carbon dioxide into a protected space and to ensure the activation of the alarm. One control shall be used for opening the valve of the piping which conveys the gas into the protected space and a second control shall be used to discharge the gas from its storage containers. Positive means (see Note 1) shall be provided so they can only be operated in that order; and
   - the two controls are to be located inside a release box clearly identified for the particular space. If the box containing the controls is locked, a key to the box is to be in a break-glass-type enclosure conspicuously located adjacent to the box.

Note 1: The "positive means", referred to for the correct sequential operation of the controls, is to be achieved by a mechanical and/or electrical interlock that does not depend on any operational procedure to achieve the correct sequence of operation

3.2.3 High-pressure carbon dioxide systems

a) The system is to be designed for an ambient temperature range of 0°C/55°C, as a rule.
b) Containers for the storage of the fire-extinguishing medium are to be designed and tested in accordance with the relevant requirements of Part C, Chapter 1.
c) The filling ratio of carbon dioxide bottles is to be normally 0,67 kg/l, or less, of the total internal volume; however, for bottles to be fitted in ships which are to operate solely outside the tropical zone, the filling ratio may be 0,75 kg/l.
d) Piping and accessories are to generally satisfy the relevant requirements of Part C, Chapter 1.
e) For systems where carbon dioxide is stored at ambient temperature, the thickness of steel pipes is not to be less than the values given in Tab 1.

   Slightly smaller thicknesses may be accepted provided they comply with national standards.

   The thickness of threaded pipes is to be measured at the bottom of the thread.
f) Pipes are to be appropriately protected against corrosion. Steel pipes are to be, at least, zinc or paint coated, except those fitted in machinery spaces, with the reservation of the Society's acceptance.
g) After mounting onboard, and in complement to tests and inspections at the Manufacturer's workshop, as per requirements of Part C, Chapter 1, carbon dioxide pipes and their accessories are to undergo the following tests:
   - pipe lengths between bottles and master valves:

     hydraulic test, at the workshop or on board, at 128 bar. When the hydraulic test is carried out at the workshop, at least test with inert gas or air, at 7 bar, is to be carried out on board.
   - pipe lengths between master valves and nozzles:

     test on board with inert gas or air, at 7 bar.

   The master valves are to undergo a hydraulic test at 128 bar.

Table 1 : Minimum wall thickness of steel pipes for CO_2 fire-extinguishing systems

Externaldiameter (mm)	Minimum wall thickness, in mm	
	Between bottles and master valves	Between master valves and nozzles
21,3 - 26,9	3,2	2,6
30,0 - 48,3	4,0	3,2
51,0 - 60,3	4,5	3,6
63,5 - 76,1	5,0	3,6
82,5 - 88,9	5,6	4,0
101,6	6,3	4,0
108,0 - 114,3	7,1	4,5
127,0	8,0	4,5
133,0 - 139,7	8,0	5,0
152,4 - 168,3	8,8	5,6

3.3 Equivalent fixed gas fire-extinguishing systems

3.3.1 In addition to [3.1], equivalent fixed gas fire-extinguishing systems are to comply with the requirements of the IMO Circular MSC/Circ. 848 (only if installed on board before 1 July 2012) or of the IMO Circular MSC.1/Circ. 1267.

4 Fixed pressure water-spraying and water-mist systems

4.1 Fixed pressure water-spraying fire-extinguishing systems

4.1.1 Installation in machinery spaces

Yachts on which a fixed water-spraying system is installed in machinery spaces are to comply with the following items:

a) Nozzles and pumps
   1) The number and arrangement of the nozzles is to be such as to ensure an effective average distribution of water of at least 5 l/m^2/minute in the spaces to be protected. Where increased application rates are considered necessary, these are to be to the satisfaction of the Society.
   2) Precautions are to be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.
   3) The pump is to be capable of simultaneously supplying at the necessary pressure all sections of the system in any one compartment to be protected.
   4) The pump may be driven by independent internal combustion machinery, but, if it is dependent upon power being supplied from the emergency generator fitted in compliance with the provisions of Ch 2, Sec 2, [2.3], the generator is to be so arranged as to start automatically in case of main power failure so that power for the pump required in item 3) above is immediately available. The independent internal combustion machinery for driving the pump is to be so situated that a fire in the protected space or spaces will not affect the air supply to the machinery.

b) Installation requirements
   1) Nozzles are to be fitted above bilges, tank tops and other areas over which oil fuel is liable to spread and also above other specific fire hazards in the machinery spaces.
   2) The system may be divided into sections, the distribution valves of which are to be operated from easily accessible positions outside the spaces to be protected so as not to be readily cut off by a fire in the protected space.
   3) The pump and its controls are to be installed outside the space or spaces to be protected. It is not to be possible for a fire in the space or spaces protected by the water-spraying system to put the system out of action.

c) System control requirements

   The system is to be kept charged at the necessary pressure and the pump supplying the water for the system is to be put automatically into action by a pressure drop in the system.

4.1.2 Installation in vehicle spaces

Yachts on which a fixed water-spraying system is installed in vehicle spaces are to comply with the following items:

a) Nozzles and pumps
   1) The number and arrangement of the nozzles is to be such as to ensure an effective average distribution of water of at least 3,5 l/m^2/minute in the spaces to be protected. Where increased application rates are considered necessary, these are to be to the satisfaction of the Society.
   2) Precautions are to be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.
   3) The pump or pumps is to be capable of providing simultaneously, at all times, a sufficient supply of water at the required pressure to all nozzles of the system or at least to those of two sections.
   4) The pump may be driven by independent internal combustion machinery, but, if it is dependent upon power being supplied from the emergency generator fitted in compliance with the provisions of Ch 2, Sec 2, [2.3], the generator is to be so arranged as to start automatically in case of main power failure so that power for the pump required in item 3) is immediately available. The independent internal combustion machinery for driving the pump is to be so situated that a fire in the protected space or spaces will not affect the air supply to the machinery.

b) Installation requirements

   An even water distribution to the whole space to be protected is to be ensured. The distribution valves for the system are to be located in an easily accessible position, adjacent to but outside the space to be protected, which will not readily be cut off by a fire within the space. Direct access to the distribution valves from the space and from outside the space is to be provided.

c) System control requirements

   The pump or pumps are to be capable of being brought into operation by remote control from the same position at which the distribution valves are located.

4.2 Equivalent water-mist fire-extinguishing systems

4.2.1 Installation in machinery spaces

Yachts on which an equivalent water-mist system is installed in machinery spaces are to comply with the requirements of IMO Circular MSC/Circ. 1165 and its amendments.

4.2.2 Installation in vehicle spaces

a) If a manual water mist system is installed, nozzles should comply with the requirements of the IMO Circular MSC.1/Circ. 1272. If working pressures are compatible, the nozzles piping may be a section of the fixed water-mist system protecting the machinery spaces, with the isolating valve located outside the vehicle space.

b) Alternatively, if the system has not been fire tested in accordance with the IMO Circular MSC.1/Circ. 1272, it may be possible to install nozzles which have been tested in accordance with the IMO Circular MSC/Circ. 1165, providing the nozzles spacing is reduced to half the spacing required in an equivalent engine room.

5 Automatic sprinkler, fire detection and fire alarm systems

5.1 Conventional sprinkler system

5.1.1 General

a) Yachts on which a conventional automatic sprinkler, fire detection and fire alarm system is installed are to comply with item b) bellow and with requirements [5.1.2] to [5.1.5].

b) Type of sprinkler systems

   The automatic sprinkler systems are to be of the wet pipe type, but small exposed sections may be of the dry pipe type where, in the opinion of the Society, this is a necessary precaution.

5.1.2 Sources of power supply

There are to be not less than two sources of power supply for the sea water pump and automatic alarm and detection system. If the pump is electrically driven, it is to be connected to the main source of electrical power, which is to be capable of being supplied by at least two generators. The feeders are to be so arranged as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk except in so far as it is necessary to reach the appropriate switchboards. One of the sources of power supply for the alarm and detection system is to be an emergency source. Where one of the sources of power for the pump is an internal combustion engine, it is, in addition to complying with the provisions of [5.1.4], item c), to be so situated that a fire in any protected space will not affect the air supply to the machinery.

5.1.3 Component requirements

a) Sprinklers

   The sprinklers are to be resistant to corrosion by the marine atmosphere. In accommodation and service spaces the sprinklers are to come into operation within the temperature range from 68°C to 79°C, except that in locations such as drying rooms, where high ambient temperatures might be expected, the operating temperature may be increased by not more than 30°C above the maximum deckhead temperature.

b) Sprinkler pumps

   1) An independent power pump is to be provided solely for the purpose of continuing automatically the discharge of water from the sprinklers. The pump is to be brought into action automatically by the pressure drop in the system before the standing fresh water charge in the pressure tank is completely exhausted.

   2) The pump and the piping system are to be capable of maintaining the necessary pressure at the level of the highest sprinkler to ensure a continuous output of water sufficient for the coverage of the space with the greatest hydraulic demand. For the purposes of this calculation, the design area used to calculate the required flow and pressure should be the most hydraulically demanding space on a single deck area, separated from adjacent spaces by A-class divisions. For yachts less than 500 GT, the most hydraulically demanding space on a single deck area, separated from adjacent spaces by B-class divisions can be used instead. For all yachts, the design area need not exceed 150 m^2. The hydraulic capability of the system is to be confirmed by the review of hydraulic calculations, followed by a test of the system, if deemed necessary by the Society.

   3) The pump is to be fitted on the delivery side with a test valve with a short open-ended discharge pipe. The effective area through the valve and pipe is to be adequate to permit the release of the required pump output while maintaining the pressure in the system specified in item b) 1) above.

5.1.4 Installation requirements

a) General

Any parts of the system which may be subjected to freezing temperatures in service are to be suitably protected against freezing.

b) Piping arrangements

1) Sprinklers are to be grouped into separate sections, each of which is to contain not more than 200 sprinklers. Any section of sprinklers is not to serve more than two decks and is not to be situated in more than one main vertical zone. However, the Society may permit such a section of sprinklers to serve more than two decks or be situated in more than one main vertical zone, if it is satisfied that the protection of the ship against fire will not thereby be reduced.

2) Each section of sprinklers is to be capable of being isolated by one stop-valve only. The stop-valve in each section is to be readily accessible in a location outside of the associated section or in cabinets within stairway enclosures. The valve's location is to be clearly and permanently indicated. Means are to be provided to prevent the operation of the stop-valves by any unauthorized person.

3) A test valve is to be provided for testing the automatic alarm for each section of sprinklers by a discharge of water equivalent to the operation of one sprinkler. The test valve for each section is to be situated near the stop-valve for that section.

4) The sprinkler system has to have a connection from the ship’s fire main by way of a lockable screw-down non-return valve at the connection which will prevent a backflow from the sprinkler system to the fire main.

The automatic sprinkler fire detection and fire alarm system is to be an independent unit and therefore no other piping system is to be connected to it, except for the following:

- connections for feeding the system from shoreside sources, fitted with adjacent stop valves and non-return valves
- connection from the fire main as required above.

The valves on the shore filling connection and on the fire main connection are to be fitted with clear and permanent labels indicating their service. These valves are to be capable of being locked in the "closed" position.

5) A gauge indicating the pressure in the system is to be provided at each section stop-valve and at a central station.

6) The sea inlet to the pump is to, wherever possible, be in the space containing the pump and is to be so arranged that when the ship is afloat it will not be necessary to shut off the supply of sea water to the pump for any purpose other than the inspection or repair of the pump.

c) Location of systems

The sprinkler pump are to be situated in a position reasonably remote from any machinery space of category A and are not to be situated in any space required to be protected by the sprinkler system.

5.1.5 System control requirements

a) Ready availability

1) Any required automatic sprinkler, fire detection and fire alarm system is to be capable of immediate operation at all times and no action by the crew is to be necessary to set it in operation.

2) The automatic sprinkler system is to be kept charged at the necessary pressure and has to have provision for a continuous supply of water as required in this Section.

b) Alarm and indication

1) Each section of sprinklers is to include means for giving a visual and audible alarm signal automatically at one or more indicating units whenever any sprinkler comes into operation. Such alarm systems are to be such as to indicate if any fault occurs in the system. Such units are to indicate in which section served by the system a fire has occurred and are to be centralized on the navigation bridge or in the continuously-manned central control station and, in addition, visible and audible alarms from the unit are also to be placed in a position other than on the aforementioned spaces to ensure that the indication of fire is immediately received by the crew.

2) Switches are to be provided at one of the indicating positions referred to in the previous item 1) which will enable the alarm and the indicators for each section of sprinklers to be tested.

3) Sprinklers are to be placed in an overhead position and spaced in a suitable pattern to maintain an average application rate of not less than 5 l/m^2/minute over the nominal area covered by the sprinklers. However, the Society may permit the use of sprinklers providing such an alternative amount of water suitably distributed as has been shown, to the satisfaction of the Society, to be not less effective.

4) A list or plan is to be displayed at each indicating unit showing the spaces covered and the location of the zone in respect of each section. Suitable instructions for testing and maintenance are to be available.

c) Testing

Means are to be provided for testing the automatic operation of the pump on reduction of pressure in the system.

5.2 Equivalent water-mist sprinkler systems

5.2.1 Application

Yachts on which an equivalent automatic sprinkler, fire detection and fire alarm system is installed are to comply with the requirements of the IMO Resolution A.800(19) (only if installed on board before 1 July 2015) or of the IMO Resolution MSC 265(84), except that:

a) Paragraph [3.3] of the annex of the above mentioned resolutions is replaced by:

   The sprinkler system should be capable of continuously supplying the water-based extinguishing medium for a minimum of 30 min.

b) Paragraph [3.8] of the annex of the above mentioned resolutions is replaced by requirement [5.1.2].

c) Paragraph [3.22] of the annex of the above mentioned resolutions is replaced by requirement [5.2.2].

5.2.2 Sprinkler pumps capacity requirements

Pumps and alternative supply components should be capable of supplying the required flow rate and pressure for the space with the greatest hydraulic demand. For the purposes of this calculation, the design area used to calculate the required flow and pressure should be the most hydraulically demanding space on a single deck area, separated from adjacent spaces by A-class divisions. For yachts less than 500 GT, the most hydraulically demanding space on a single deck area, separated from adjacent spaces by B-class divisions can be used instead. For all yachts, the design area need not exceed 150 m^2.

6 Fixed fire detection and fire alarm systems

6.1 Engineering specifications

6.1.1 General requirements

a) Any required fixed fire detection and fire alarm system (with manually operated call points, if required by Ch 4, Sec 3, [6]) is to be capable of immediate operation at all times.

   Notwithstanding this, particular spaces may be disconnected, for example, workshops during hot work and ro-ro spaces during on and off-loading. The means for disconnecting the detectors shall be designed to automatically restore the system to normal surveillance after a predetermined time that is appropriate for the operation in question. The space shall be manned or provided with a fire patrol when detectors required by regulation are disconnected. Detectors in all other spaces shall remain operational.

b) The fixed fire detection and fire alarm system are not to be used for any other purpose

c) The system and equipment are to be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in yachts.

d) Detectors and manual call points shall be connected to dedicated sections of the fire detection system. Other fire safety functions, such as alarm signals from the sprinkler valves, may be permitted if in separate sections.

e) Fixed fire detection and fire alarm systems with individually identifiable fire detectors shall be so arranged that:

   1) means are provided to ensure that any fault (e.g. power break, short circuit, earth, etc.) occurring in the section will not prevent the continued individual identification of the remainder of the connected detectors in the section

   2) all arrangements are made to enable the initial con-figuration of the system to be restored in the event of failure (e.g. electrical, electronic, informatics, etc.)

   3) the first initiated fire alarm will not prevent any other detector from initiating further fire alarms; and

   4) no section will pass through a space twice. When this is not practical (e.g. for large public spaces), the part of the section which by necessity passes through the space for a second time shall be installed at the maximum possible distance from the other parts of the section.

f) In yachts of 500 GT and over, the fixed fire detection and fire alarm system shall be capable of remotely and individually identifying each detector and manually operated call point.

6.1.2 Sources of power supply

a) There shall be not less than two sources of power supply for the electrical equipment used in the operation of the fixed fire detection and fire alarm system, one of which shall be an emergency source of power. The supply shall be provided by separate feeders reserved solely for that purpose. Such feeders shall run to an automatic change-over switch situated in, or adjacent to, the control panel for the fire detection system. The change-over switch shall be arranged such that a fault will not result in the loss of both power supplies.

b) The operation of the automatic changeover switch or a failure of one of the power supplies shall not result in loss of fire detection capability. Where a momentary loss of power would cause degradation of the system, a battery of adequate capacity shall be provided to ensure continuous operation during change-over.

c) The emergency source of power specified in item a) above may be supplied by accumulator batteries or from the emergency switchboard. The power source shall be sufficient to maintain the operation of the fire detection and fire alarm system for the periods required under Ch 2, Sec 2, [2.3.6], Ch 2, Sec 2, [2.3.7] or Ch 2, Sec 2, [2.3.8] depending on the type of yacht and, at the end of that period, shall be capable of operating all connected visual and audible fire alarm signals for a period of at least 30 min.

d) Where the system is supplied from accumulator batteries, they shall be located in or adjacent to the control panel for the fire detection system, or in another location suitable for use in an emergency. The rating of the battery charge unit shall be sufficient to maintain the normal output power supply to the fire detection system while recharging the batteries from a fully discharged condition.

6.1.3 Detector and cables requirements

a) Detectors

1) Detectors are to be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by the Society provided that they are no less sensitive than such detectors. Flame detectors are only to be used in addition to smoke or heat detectors

2) Smoke detectors required in stairways, corridors and escape routes within accommodation spaces are to be certified to operate before the smoke density exceeds 12,5% obscuration per metre, but not until the smoke density exceeds 2% obscuration per metre. Smoke detectors to be installed in other spaces are to operate within sensitivity limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity

3) Heat detectors are to be certified to operate before the temperature exceeds 78°C but not until the temperature exceeds 54°C, when the temperature is raised to those limits at a rate less than 1°C per minute. At higher rates of temperature rise, the heat detector is to operate within temperature limits to the satisfaction of the Society having regard to the avoidance of detector insensitivity or oversensitivity

4) The operation temperature of heat detectors in drying rooms and similar spaces of a normal high ambient temperature may be up to 130°C, and up to 140°C in saunas

5) All detectors are to be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component

6) Detectors fitted in hazardous areas shall be tested and approved for such service.

b) Cables

Cables used in the electrical circuits shall be flame retardant according to standard IEC 60332-1.

6.1.4 Installation requirements

a) Sections:

1) Detectors (and manually operated call points, if required by Ch 4, Sec 3, [6]) are to be grouped into sections.

2) A section of fire detectors which covers a control station, a service space or an accommodation space is not to include a machinery space of category A.

3) Where the fixed fire detection and fire alarm system does not include means of remotely identifying each detector individually, no section covering more than one deck within accommodation spaces, service spaces and control stations is normally to be permitted except a section which covers an enclosed stairway. In order to avoid delay in identifying the source of fire, the number of enclosed spaces included in each section is to be limited as determined by the Society. In no case more than fifty enclosed spaces are to be permitted in any section. If the system is fitted with remotely and individually identifiable fire detectors, the sections may cover several decks and serve any number of enclosed spaces

b) Position of detectors:

1) Detectors are to be located for optimum performance. Positions near beams and ventilation ducts or other positions where patterns of air flow could adversely affect performance and positions where impact or physical damage is likely are to be avoided. Detectors which are located on the overhead are to be at a minimum distance of 0,5 m away from bulkheads, except in corridors, lockers and stairways

2) The maximum spacing of detectors is to be in accordance with Tab 2. The Society may require or permit different spacing to that specified in Tab 2 if based upon test data which demonstrate the characteristics of the detectors

3) Detectors in stairways shall be located at least at the top level of the stair and at every second level beneath

4) When fire detectors are installed in freezers, drying rooms, saunas, parts of galleys used to heat food, laundries and other spaces where steam and fumes are produced, heat detectors may be used.

c) Arrangement of cables:

1) Cables which forms part of the system is to be so arranged as to avoid galleys, machinery spaces of category A and other enclosed spaces of high fire risk except where it is necessary to provide for fire detection or fire alarms in such spaces or to connect to the appropriate power supply

2) A section with individually identifiable capability shall be arranged so that it cannot be damaged at more than one point by a fire.

Table 2 : Spacing of detectors

Type of detector	Maximum floor area per detector	Maximum distance apart between centres	Maximum distance away from bulkheads
Heat	37 m^2	9 m	4,5 m
Smoke	74 m^2	11 m	5,5 m

6.1.5 System control requirements

a) Visual and audible fire signals:

1) The activation of any detector or manually operated call point is to initiate a visual and audible fire signal at the control panel and indicating units. If the signals have not received attention within two minutes, an audible alarm is to be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces of category A. This alarm sounder system need not be an integral part of the detection system

2) The control panel is to be located on the navigation bridge or in the continuously manned central control station

3) Indicating units are, as a minimum, to denote the section in which a detector has been activated. At least one unit is to be so located that it is easily accessible to responsible members of the crew at all times. One indicating unit is to be located on the navigation bridge if the control panel is located in the main fire control station

4) Clear information is to be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections

5) Power supplies and electric circuits necessary for the operation of the system are to be monitored for loss of power or fault conditions as appropriate. Occurrence of a fault condition is to initiate a visual and audible fault signal at the control panel which is to be distinct from a fire signal.

b) Testing:

Suitable instructions and component spares for testing and maintenance are to be provided.

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