Hull Structure and Arrangement for the Classification of Cargo Ships less than 65 m and Non Cargo Ships less than 90 m
Hull Structure and Arrangement for the Classification of Cargo Ships less than 65 m and Non Cargo Ships less than 90 m

December 2017

Rule Note
NR 600 DT R02 E
1. INDEPENDENCY OF THE SOCIETY AND APPLICABLE TERMS
1.1. The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or sub-contractors shall be liable as or act as an employee, servant or agent of the Client or in any capacity for any failure or delay in the performance of the Services. The Society will not, involve, for the part carried out, the payment of fees thirty (30) days such payment is delinquent. The Society shall also have the right to withhold certificates and other documents and/or to suspend or re-voke the valid of certificates.
6. PAYMENT OF INVOICES
6.1. The provision of the Services by the Society, whether complete or incomplete, involves, for the Client, the payment of fees thirty (30) days upon issuance of the invoice.
6.2. Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interests equal to twelve (12) months LIBOR plus two (2) per cent per annum paid on the date of the number of days such payment is delinquent. The Society shall also have the right to exercise proceedings before a court for the recovery of such amounts and/or to suspend or re-voke the valid of certificates.
6.3. In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid while the dispute shall accompany payment so that action can be taken to solve the dispute.
7. LIABILITY
7.1. The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:
• Indirect or consequential loss;
• Any loss and/or defrayment of profit, loss of use, loss of bargain, loss of revenue, loss of anticipated profit, loss of business and interruption of business, in each case whether direct or indirect.
7.2. The Client shall save, indemnify and hold harmless the Society from the Client's own consequential loss regardless of cause.
7.2. In any case, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cent (150%) of the price paid by the Client to the Society for the performance of the Services. This limit applies regardless of fault by the Society, including breach of contract, breach of warranty, tort, strict liability, breach of statute.
7.3. All claims shall be presented to the Society in writing within three (3) months from the date of the incident, occurrence or failure or loss of property loss or damage. Any claim not so presented as defined above shall be deemed waived and barred.
8. INDEMNITY CLAUSE
8.1. The Client agrees to release, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions, whether in law or in equity, whether in a court or arbitrator, whether for injury to persons or property, tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the Services, including but not limited to those claims caused solely and completely by the negligence of the Society, its officers, employees, servants, agents or sub-contractors.
9. TERMINATION
9.1. The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.
9.2. In such a case, the class granted to the concerned Unit and the previously issued certificates shall remain valid until the date of the effect of the termination notice issued, subject to compliance with clause 4.1 and 6 above.
10.1. Neither Party shall be responsible for any failure to fill any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence which, in the opinion of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.
10.2. The Client agrees to inform the Party of such an occurrence, which, in the Party's opinion, makes it impossible to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.
11. CONFIDENTIALITY
11.1. The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, are treated as confidential except where the information:
• is already known by the receiving Party from another source and is properly and lawfully in the possession of the receiving Party prior to disclosure; or
• is already in possession of the public or has entered the public domain, otherwise than through a breach of this obligation;
• is acquired independently from a third party that has the right to disseminate said information;
• is required to be disclosed under applicable law or by a government order, decree, regulation or rule or by a stock exchange authority (pursuant to mandatory legal obligations).
12. INTELLECTUAL PROPERTY
12.1. Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.
12.2. The Intellectual Property developed for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain exclusive property of the Society.
13. ASSIGNMENT
13.1. The Client is not entitled to assign or transfer from to these Conditions can be assigned or transferred by any means by a Party to a third party without the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.
13.2. Neither Party shall have the right to disclose the confidential information to be disclosed under regulations of the International Association of Classification Societies (IACS) or any statutory obligations.
14. SEVERABILITY
14.1. Invalidity of one or more provisions does not affect the remaining provisions.
14.2. Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.
14.3. In case of doubt as to the interpretation of the Conditions, the English text shall prevail.
15. GOVERNING LAW AND DISPUTE RESOLUTION
15.1. The Conditions shall be construed and governed by the laws of England and Wales.
15.2. The Client and the Society shall make every effort to settle any dispute amicably and in good faith by way of negotiation within thirty (30) days from the date of receipt by either one of the Parties of a writ-ten notice of such a dispute.
15.3. Failing that, the dispute shall finally be settled by arbitration under the LCIA rules, which rules are deemed to be interpreted by refer-ence to the English language. The place of arbitration shall be London (UK).
16. PROFESSIONAL ETHICS
16.1. Each Party shall conduct all activities in compliance with all laws, statutory rules, and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimi-nation, abuse, working hours and minimum wages, anti-bribery, anti-corruption law of the Party's country or jurisdiction, and any other law or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence which, in the opinion of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.
NR 600
Hull Structure and Arrangement for the Classification of Cargo Ships less than 65 m and Non Cargo Ships less than 90 m

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Chapter 2 Structure Design Principles, General Arrangement and Scantling Criteria
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December 2017
Unless otherwise specified, these rules apply to ships for which contracts are signed after December 1\textsuperscript{st}, 2017. The Society may refer to the contents hereof before December 1\textsuperscript{st}, 2017, as and when deemed necessary or appropriate.
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NR 600

Chapter 1

GENERAL

SECTION 1  GENERAL
SECTION 2  MATERIALS
SECTION 3  SCANTLING PRINCIPLE
SECTION 1  
GENERAL

1 Application criteria

1.1 Types of ships covered by the present Rules

1.1.1 General
The present Rules contain the requirements for the determination of the hull scantlings (fore, central and aft parts of the ship) and structure arrangement applicable to the following type of ships of normal form, speed and proportions and built in steel, aluminium, or composite materials:

- cargo ships with a length \( L \) less than 65 m
- non cargo ships with a length \( L \) less than 90 m.

Note 1: For definition of cargo ships and non cargo ships, refer to [2.1.2].

1.1.2 Hull shape
In the present Rules, the hull loadings are estimated considering the hull shape of the two following types of hull:

- 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.

1.1.3 Navigation notations
Any ships covered by the present Rules are to be assigned one of the following navigation notations:

- unrestricted navigation
- summer zone
- tropical zone
- coastal area
- sheltered area.

as defined in NR467 Steel Ships, Pt A, Ch 1, Sec 2, [5.2], except those having the service notation launch or seagoing launch.

1.1.4 Additional requirements applicable to specific ships
a) ships in aluminium
Specific additional requirements applicable to ships built in aluminium materials are defined in NR561 Aluminium Ships.
b) ships in composite materials
Specific additional requirements applicable to ships built in composite and/or plywood materials are defined in NR546 Composite Ships.

1.2 Types of ships not covered by the present Rules

1.2.1 Liquefied gas carrier
Ships having the service notation liquefied gas carrier are not covered by the present Rules and are to be in accordance with NR467 Steel Ships, Part B and Part D, Chapter 9.

1.2.2 Cargo ships with alternate light and heavy cargo loading conditions
As a rule, for ships having alternate light and heavy cargo loading conditions, the scantlings may be determined from NR467 Steel Ships, Part B, Chapter 7 instead of the present Rules, when deemed necessary by the Society.

1.2.3 High speed craft
Ships having:
- one of the service notations HSC-CAT A, HSC-CAT B, HSC, light ship, crew boat, and
- a navigation notation corresponding to sea areas defined on the basis of sea states characterised by a significant wave height,

are not covered by the present Rules.

1.3 Particular cases

1.3.1 Hull scantling
The Society reserves its right, whenever deemed necessary, to apply the requirements defined in NR467 Steel Ships (Rules dedicated to ships greater than 65 m in length) in lieu of the present Rules (see Sec 3, [2]).

1.3.2 Subdivision, compartment arrangement, arrangement of hull openings and freeing ports
The requirements to be applied for the subdivision of the hull, the compartment arrangement and the arrangement of hull openings are defined in Ch 2, Sec 2, Tab 1.

2 General

2.1 Wording

2.1.1 Rules
In the present Rules, the references to other Rules of the Society are defined in Tab 1.
2.1.2 Ship groups: Cargo ships and non cargo ships

In the present Rules, the wording “cargo ships” and “non cargo ships” means:

- **cargo ships**
  ships liable to carry cargoes and having a deadweight greater than 30% of the total displacement. These ships are fitted with cargo holds, tanks and lateral ballast tanks used in non loaded conditions (i.e. bulk or ore carriers, oil or chemical tankers, container ships, general cargo ships,...). As a rule, the value of the block coefficient is greater than 0,75

- **non cargo ships**
  - type of ships other than cargo ships defined here above, or
  - ships having a deadweight greater than 30% of the total displacement and not fitted with lateral ballast tanks used in non loaded navigation condition.

2.1.3 Multihull

In the present Rules, “multihull” means a ship with two hulls (floats) connected to a platform structure.

A multihull with more than two floats is to be considered on a case-by-case basis.

Two types of multihulls are considered in the present Rules:

- **Catamaran**: multihull which may be of displacement hull type or planing hull type, according to its design
- **Swath (Small Waterplane Area Twin Hull ship)**: multihull with two submerged floats connected to the platform structure by narrow struts.

As a rule, a swath is not to be considered as ship having a planing hull and is not subjected to slamming impacts on bottom.

2.1.4 Planing hull

In the present Rules, “planing hull” defines a ship having a planing hull shape and able to sail:

- in planing mode, when the actual speed and sea state do not allow to sail in planing mode without exceeding the expected design vertical acceleration.

The Designer defines whether both the ship is designed to sail in planing mode and 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 $V \geq 10 \cdot L_{WL}^{0.5}$ are individually considered by the Society, where:

\[ V : \text{Speed of the ship, in knots} \]
\[ L_{WL} : \text{Waterline length, as defined in [4.2.5].} \]

Note 1: As a guidance, a ship may be considered as able to sail in planing hull mode when:

\[ V \geq 7.16 \cdot \Delta^{0.5} \]

with:

\[ \Delta : \text{Displacement of the ship, as defined in [4.6.1].} \]

2.2 Classification

2.2.1 General

Ships complying with the requirements of the present Rules are to comply with the requirements of NR467 Steel Ships, Part A (Classification and Surveys).

2.2.2 Service notations and additional service features

The assignment of any service notation and any additional service feature, as defined in NR467 Steel Ships, Part A, is subject to compliance with the general requirements laid down in the present Rules and especially with the additional requirements laid down in Ch 6, Sec 1, as applicable.

2.2.3 Additional class notations

In addition to the present Rules, additional requirements of NR467 Steel Ships, Part F are to be considered, in relation to the additional class notations requested by the Interested Party.

3 Navigation coefficient

3.1 Ships with a navigation notation

3.1.1 The navigation coefficient $n$, depending on the assigned navigation notation as defined in NR467 Steel Ships, Part A, Chapter 1, Sec 2, [5.2], is given in Tab 2.

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<td>unrestricted navigation</td>
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<tr>
<td>summer zone</td>
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<tr>
<td>tropical zone</td>
<td>0.80</td>
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<tr>
<td>coastal area</td>
<td>0.80</td>
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<td>sheltered area</td>
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</table>
3.2 Sea going launch and launch

3.2.1 For ships having the service notation sea going launch or launch, as defined in NR467 Steel Ships, Part A, Chapter 1, Sec 2, [4.15.2], the navigation coefficient n is as given in Tab 3.

<table>
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</tbody>
</table>

Note 1: Lw : Length as defined in [4.2.6].

4 Definitions

4.1 Moulded base line

4.1.1 The moulded base line is the horizontal line located at the upper face of the bottom plating or at the intersection between the upper face of the bottom plating and the solid bar keel.

For ships designed with a rake of keel, the base line is to be as defined above, at a point located at the midship section.

4.2 Lengths

4.2.1 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.

4.2.2 Ends of the rule length

The fore end (FP) of the rule length L is the perpendicular to the summer load waterline at the fore side of the stem. The aft end (AP) of the rule length L is the perpendicular to the summer load waterline at a distance L aft of FP.

4.2.3 Midship LCG

The midship LCG is the perpendicular to the summer load waterline at a distance 0,5 L aft of FP.

4.2.4 Hull length LHULL

The hull length LHULL is equal to the distance, in m, measured from the fore end of the hull to the aft end of the hull.

4.2.5 Waterline length LWL

The waterline length LWL 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.

4.2.6 Length Lw

The length Lw is to be taken equal to:

Lw = 0,5 (LWL + LHULL)

4.3 Breadth

4.3.1 Moulded breadth B

The moulded breadth B is the greatest moulded breadth, in m, measured amidships below the weather deck.

4.3.2 Waterline breadths BWL and BST

The waterline breadth BWL is the breadth of the hull, in m, measured amidships at the moulded draught.

For a catamaran, the waterline breadth BWL is to be measured amidships at one float, at moulded draught.

For a swath, the waterline breadth BST is to be measured amidships at one strut, at moulded draught.

4.3.3 Breadth BS between multihull floats

The breadth BS 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 BWL or 0,5 BST.

4.3.4 Breadth BSF of swath submerged float

The moulded breadth BSF of a swath submerged float is the greatest moulded breadth of the submerged float, in m, measured amidships.

4.4 Depth D

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

In the case of ships 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 midship LCG.

4.5 Moulded draught T

4.5.1 The moulded draught T is the distance, in m, measured vertically on the midship transverse section, from the moulded base line to the top of the deck beam at the summer load waterline.

In the case of ships with a solid bar keel, the moulded base line is to be taken as defined in [4.4.1].

4.6 Total block coefficient CB

4.6.1 The total block coefficient CB is to be taken equal to:

- for monohull:
  \[ C_B = \frac{\Delta}{1,025 L_{W}} \]

- for catamaran:
  \[ C_B = \frac{\Delta}{1,025 L_{W} \times 2} \]

- for swath:
  \[ C_B = \frac{\Delta}{1,025 L_{W} \times 2 B_m T} \]
  with:
  \[ B_m = B_{m2} D_{N} + B_{m1} (T - D_{N}) \]
where:
\[ \Delta \] : Moulded displacement, in tonnes, at draught T, in sea water (density \( \rho = 1,025 \text{ t/m}^3 \))
\[ L_{\text{WLL}} \] : Waterline length, in m, as defined in [4.2.5]
\[ B_{\text{WLL}}, B_{\text{SF}}, B_{\text{ST}} \] : Breadths, in m, measured amidships, as defined in [4.3.2] and [4.3.4]
\[ D_{\text{SF}} \] : Depth, in m, of the submerged float amidships
\[ T \] : Moulded draught, as defined in [4.5.1].

4.7 Chine and bottom

4.7.1 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.

4.7.2 Bottom
The bottom is the part of the hull between the centre line of the hull or the float and the chines.

4.8 Lightweight

4.8.1 The lightweight is the displacement, in t, without cargo, fuel, lubricating oil, ballast water, fresh water and feed water, consumable stores and passengers and crew and their effects, but including liquids in piping.

4.9 Deadweight

4.9.1 The deadweight is the difference, in t, between the displacement, at the summer draught in sea water of density \( \rho = 1,025 \text{ t/m}^3 \), and the lightweight.

4.10 Freeboard deck

4.10.1 The freeboard deck is defined in Regulation 3 of the 1966 International Convention on Load Lines, as amended.

4.11 Bulkhead deck

4.11.1 The bulkhead deck in a passenger ship means the uppermost deck at any point in the subdivision length \( L_5 \) to which the main bulkheads and the ship shell are carried watertight. In a cargo ship, the freeboard deck may be taken as the bulkhead deck.

Note 1: The subdivision \( L_5 \) of a ship is the greatest projected moulded length of that part of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught.

4.12 Superstructure

4.12.1 General
A superstructure is a decked structure connected to 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 0,04 B.

4.12.2 Superstructure deck
A superstructure deck is a deck forming the upper boundary of a superstructure.

4.12.3 Deckhouse
A deckhouse is a decked structure other than a superstructure, located on the freeboard deck or above.

4.12.4 Standard height of superstructure \( h_S \)
The standard height of superstructure \( h_S \) is defined in Tab 4.

Table 4 : Standard height of superstructure \( h_S \)

<table>
<thead>
<tr>
<th>Load line length ( L_{\text{LL}} ) in m</th>
<th>Standard height ( h_S ) in m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raised quarterdeck</td>
</tr>
<tr>
<td>( L_{\text{LL}} \leq 30 )</td>
<td>0,90</td>
</tr>
<tr>
<td>( 30 &lt; L_{\text{LL}} &lt; 75 )</td>
<td>( 0,9 + 0,00667 ) (( L_{\text{LL}} - 30 ))</td>
</tr>
<tr>
<td>( 75 \leq L_{\text{LL}} &lt; 90 )</td>
<td>( 1,2 + 0,012 ) (( L_{\text{LL}} - 75 ))</td>
</tr>
</tbody>
</table>

4.12.5 Tiers of superstructures and deckhouses
The lowest tier is the tier located immediately above the freeboard deck.
The second tier is the tier located immediately above the lowest tier, and so on.

4.13 Multihull platform

4.13.1 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.

5 Reference co-ordinate system

5.1 General

5.1.1 The ship’s geometry, motions, accelerations and loads are defined with respect to the following right-hand co-ordinate system (see Fig 1):
- Origin: at the intersection between the longitudinal plane of symmetry of ship, the aft end of L and the baseline
- X axis: longitudinal axis, positive forwards
- Y axis: transverse axis, positive towards portside
- Z axis: vertical axis, positive upwards.

5.1.2 Positive rotations are oriented in anti-clockwise direction about the X, Y and Z axes.
Figure 1: Reference co-ordinate system

6 Stability

6.1 General

6.1.1 For information, intact stability and damage stability are to comply with the following Rules:

- For non-propelled ships and ships of less than 500 GT:
  - passenger ship with unrestricted navigation: NR467 Steel Ships
  - ro-ro passenger ship with unrestricted navigation: NR467 Steel Ships
  - chemical tanker: NR467 Steel Ships
  - fishing vessel: NR467 Steel Ships
  - ships with other service notations: NR566
- For ships of 500 GT and over: NR467 Steel Ships.

7 Documentation to be submitted

7.1 Documentation to be submitted

7.1.1 Plans and documents to be submitted for approval

The plans and documents to be submitted to the Society for approval are listed in Tab 5. Structural plans are to show details of connections of the various parts and to specify the materials used, including their manufacturing processes (see also Chapter 7).

7.1.2 Plans and documents to be submitted for information

In addition to those in [7.1.1], the following plans and documents are to be submitted to the Society, for information:

- general arrangement
- capacity plan indicating, for all the compartments and tanks, their volume and the position of their centre of gravity
- lightweight distribution.

Moreover, when direct calculation analyses are carried out by the Designer according to the rule requirements, they are to be submitted to the Society.

Table 5: Documentation to be submitted for approval for all ships

<table>
<thead>
<tr>
<th>Plan or document</th>
<th>Containing also information on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midship section</td>
<td>Class characteristics</td>
</tr>
<tr>
<td>Transverse sections</td>
<td>Main dimensions</td>
</tr>
<tr>
<td>Shell expansion</td>
<td>Minimum ballast draught</td>
</tr>
<tr>
<td>Decks and profiles</td>
<td>Frame spacing</td>
</tr>
<tr>
<td>Double bottom</td>
<td>Contractual service speed</td>
</tr>
<tr>
<td>Pillar arrangements</td>
<td>Density of cargoes</td>
</tr>
<tr>
<td>Framing plan</td>
<td>Design loads on decks and double bottom</td>
</tr>
<tr>
<td>Deep tank and ballast tank bulkheads, swash bulkheads</td>
<td>Steel grades</td>
</tr>
<tr>
<td></td>
<td>Location and height of air vent outlets of various compartments</td>
</tr>
<tr>
<td></td>
<td>Corrosion protection</td>
</tr>
<tr>
<td></td>
<td>Openings in decks and shell and relevant compensations</td>
</tr>
<tr>
<td></td>
<td>Boundaries of flat areas in bottom and sides</td>
</tr>
<tr>
<td></td>
<td>Details of structural reinforcements and/or discontinuities</td>
</tr>
<tr>
<td></td>
<td>Bilge keel with details of connections to hull structures</td>
</tr>
<tr>
<td>Watertight subdivision bulkheads</td>
<td>Openings and their closing appliances, if any</td>
</tr>
<tr>
<td>Watertight tunnels</td>
<td>Location and height of air vent outlets of various compartments</td>
</tr>
<tr>
<td>Fore part structure</td>
<td>Location and height of air vent outlets of various compartments</td>
</tr>
<tr>
<td>Transverse thruster, if any, general arrangement,</td>
<td></td>
</tr>
<tr>
<td>tunnel structure, connections of thruster with</td>
<td></td>
</tr>
<tr>
<td>tunnel and hull structures</td>
<td></td>
</tr>
<tr>
<td>Alt part structure</td>
<td>Location and height of air vent outlets of various compartments</td>
</tr>
</tbody>
</table>

(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.
<table>
<thead>
<tr>
<th>Plan or document</th>
<th>Containing also information on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery space structures</td>
<td>Type, power and r.p.m. of propulsion machinery</td>
</tr>
<tr>
<td>Foundations of propulsion machinery and boilers</td>
<td>Mass and centre of gravity of machinery and boilers</td>
</tr>
<tr>
<td>Superstructures and deckhouses</td>
<td>Extension and mechanical properties of the aluminium alloy used (where applicable)</td>
</tr>
<tr>
<td>Machinery space casing</td>
<td>Closing appliances</td>
</tr>
<tr>
<td>Bow doors, stern doors and inner doors, if any, side doors and other openings in the side shell</td>
<td>Electrical diagrams of power control and position indication circuits for bow doors, stern doors, side doors, inner doors, television system and alarm systems for ingress of water</td>
</tr>
<tr>
<td>Hatch covers, if any</td>
<td>Design loads on hatch covers</td>
</tr>
<tr>
<td></td>
<td>Sealing and securing arrangements, type and position of locking bolts</td>
</tr>
<tr>
<td></td>
<td>Distance of hatch covers from the summer load waterline and from the fore end</td>
</tr>
<tr>
<td>Movable decks and ramps, if any</td>
<td></td>
</tr>
<tr>
<td>Windows and side scuttles, arrangements and details</td>
<td></td>
</tr>
<tr>
<td>Bulwarks and freeing ports</td>
<td>Arrangement and dimensions of bulwarks and freeing ports on the freeboard deck and superstructure deck</td>
</tr>
<tr>
<td>Helicopter decks, if any</td>
<td>General arrangement</td>
</tr>
<tr>
<td></td>
<td>Main structure</td>
</tr>
<tr>
<td></td>
<td>Characteristics of helicopters: maximum mass, distance between landing gears or landing skids, print area of wheels or skids, distribution of landing gear loads</td>
</tr>
<tr>
<td>Rudder and rudder horn (1)</td>
<td>Maximum ahead service speed</td>
</tr>
<tr>
<td>Stern frame or sternpost, stern tube (1)</td>
<td></td>
</tr>
<tr>
<td>Propeller shaft boss and brackets</td>
<td></td>
</tr>
<tr>
<td>Derricks and cargo gear</td>
<td>Design loads (forces and moments)</td>
</tr>
<tr>
<td>Cargo lift structures</td>
<td>Connections to the hull structures</td>
</tr>
<tr>
<td>Sea chests, stabiliser recesses, etc.</td>
<td></td>
</tr>
<tr>
<td>Hawse pipes</td>
<td></td>
</tr>
<tr>
<td>Plan of outer doors and hatchways</td>
<td></td>
</tr>
<tr>
<td>Plan of manholes</td>
<td></td>
</tr>
<tr>
<td>Plan of access to and escape from spaces</td>
<td></td>
</tr>
<tr>
<td>Plan of tank testing</td>
<td>Testing procedures for the various compartments</td>
</tr>
<tr>
<td></td>
<td>Height of pipes for testing</td>
</tr>
<tr>
<td>Plan of watertight doors and scheme of relevant</td>
<td>Manoeuvring devices</td>
</tr>
<tr>
<td>manoeuvring devices</td>
<td>Electrical diagrams of power control and position indication circuits</td>
</tr>
<tr>
<td>Equipment number calculation</td>
<td>Geometrical elements for calculation</td>
</tr>
<tr>
<td></td>
<td>List of equipment</td>
</tr>
<tr>
<td></td>
<td>Construction and breaking load of steel wires</td>
</tr>
<tr>
<td></td>
<td>Material, construction, breaking load and relevant elongation of synthetic ropes</td>
</tr>
</tbody>
</table>

(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.
SECTION 2  MATERIALS

1  General

1.1  Application

1.1.1  This Section defines the main characteristics to take into account for steels, aluminium alloys or composite materials within the scope of the determination of the hull scantling as defined in the present Rules.

1.1.2  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.

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

2  Steels for hull structure

2.1  General

2.1.1  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.

2.1.2  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.

2.1.3  Mechanical characteristics of hull steels

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

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

Tab 1 gives, as a reminder, the mechanical properties of steels commonly used in the construction of ships.

Strength steels higher than those indicated in Tab 1 are considered by the Society, on a case-by-case basis.

Table 1: Mechanical properties of hull steels

<table>
<thead>
<tr>
<th>Steel grades</th>
<th>Minimum yield stress $R_{y,10}$, in N/mm²</th>
<th>Ultimate minimum tensile strength $R_m$, in N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-B-D-E</td>
<td>235</td>
<td>400 - 520</td>
</tr>
<tr>
<td>AH32-DH32-EH32-FH32</td>
<td>315</td>
<td>440 - 590</td>
</tr>
<tr>
<td>AH36-DH36-EH36-FH36</td>
<td>355</td>
<td>490 - 620</td>
</tr>
<tr>
<td>AH40-DH40-EH40-FH40</td>
<td>390</td>
<td>510 - 650</td>
</tr>
</tbody>
</table>

When steels with a minimum specified yield stress $R_{y,1}$ other than 235 N/mm² are used for a ship, the hull scantlings are to be determined considering the material factor $k$ defined in [2.1.4].

For ships intended to operate in areas with low temperatures (−20°C or below), the material grades of the structures exposed to low air temperatures are to be selected as defined in NR467 Steel Ships, Pt B, Ch 4, Sec 1. For ships less than 40 m in length, the selection of these materials, over the full length of the ship, may be carried out considering the material selections defined in NR467 Steel Ships for the areas located outside 0.4 L amidships.

For structural members within or adjacent to refrigerated spaces, when the design temperatures are below 0°C, the material grades are to be selected as defined in NR467 Steel Ships, Pt B, Ch 4, Sec 1.

2.1.4  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 $R_{y,1}$.

As a rule, the scantling of the structure elements is based on a steel material having a minimum yield stress $R_{y,1}$ equal to 235 N/mm², corresponding to $k = 1$.

Unless otherwise specified, the values of material factor $k$ are defined in Tab 2.

For intermediate values of $R_{y,1}$, $k$ may be obtained by linear interpolation.

Steels having a yield stress lower than 235 N/mm² or higher than 390 N/mm² are considered by the Society on a case-by-case basis.
2.1.5 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:

$$R_y = \frac{235}{k}$$

where:

$k$ : Material factor defined in [2.1.4].

3 Aluminium alloys for hull structure

3.1 Characteristics and testing

3.1.1 The characteristics of aluminium alloys to be used in the construction and their testing process are to comply with the applicable requirements of the following Rules:

- NR216 Materials and Welding
- NR561 Aluminium Ships.

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

3.1.2 Minimum yield stress for scantling criteria of hull structure

The minimum yield stress of aluminium $R_a$, in N/mm$^2$, used for the scantling criteria of the hull structure is to be taken, unless otherwise specified, equal to:

$$R_a = \frac{R'_{lim}}{k}$$

where:

$k$ : Material factor defined in [2.1.4].

$$R'_{lim}$$ : 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 $0.7 \times R'_m$ (tensile strength), where $R'_{p0.2}$ and $R'_m$ are defined in NR561 Aluminium Ships.

3.1.3 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:

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

4 Composite materials and plywood for hull structure

4.1 Characteristics and testing

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

- raw materials
- laminating process
- mechanical tests and raw material homologation.

4.2 Application

4.2.1 Attention is drawn to the use of composite and/or plywood materials from the point of view of structural fire protection. The Flag Administration may request that international convention be applied instead of the present requirements, which may entail in some cases a limitation in the use of composite and/or plywood materials.
SECTION 3  SCANTLING PRINCIPLES

Symbols

\[ L_{WL} \] : Waterline length, in m, as defined in Sec 1, [4.2.5].

1  Main scantling principles

1.1  General

1.1.1  The present Section defines the main scantling principles considered in the present Rules.

1.2  Type of ships

1.2.1  General

The motions and accelerations of a ship are calculated in relation to its group defined in Sec 1, [2.1.2] (cargo ship or non cargo ship).

Their longitudinal distribution along the ship length is split into four different areas, as follows (see Fig 1):

- first area: from the aft part to 0,25 \( L_{WL} \)
- second area: from 0,25 \( L_{WL} \) to 0,70 \( L_{WL} \)
- third area: from 0,70 \( L_{WL} \) to 0,85 \( L_{WL} \)
- fourth area: from 0,85 \( L_{WL} \) to the fore part.

The motions and accelerations of each area are calculated in the middle of the area and considered as a constant along the area.

As a rule, the ship motions and accelerations are calculated in head sea condition.

1.2.2  Specific case of planing hull

The structure of a planing hull is to be examined, resulting from its two navigation modes, both:

- as cargo ship or non cargo ship, as applicable, when the ship sails in displacement mode (when the actual sea state does not allow to sail in planing mode with an actual vertical acceleration compatible with the vertical acceleration taken into account for the ship structure design), and
- as planing hull, when the ship sails in planing mode (when the actual vertical acceleration induced by the actual sea state and speed to reach planing mode is compatible with the vertical acceleration taken into account for the ship structure design).

The global and local loads, and the permissible stresses considered to check the structure are specific to each case of navigation modes.

1.3  Corrosion addition

1.3.1  Ships in steel or aluminium alloys

As a rule, the scantlings obtained by applying the criteria specified in the present Rules for steel and aluminium structures are gross scantling, i.e. they include additions for corrosion.

1.3.2  Ships in composite materials

The scantlings obtained by applying the criteria specified in the present Rules for composite structures include a rule partial safety factor \( C_v \), which takes into account the ageing effect on the laminate mechanical characteristics.

1.4  Rounding off

1.4.1  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.

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 Hull analysis approach

2.1 Global hull girder strength and local strength

2.1.1 General
As a rule, the global hull girder strength and the local strength are examined independently in the present Rules, as follows:

- the longitudinal scantling of the hull girder and the transverse scantling of the platform of catamaran are examined on the basis of a maximum permissible stress and a buckling check of the elements contributing to the global strength in the cases listed in Ch 4, Sec 2, [1.1.3]
- the local scantling is examined on the basis of the local permissible stresses defined in relation to the type of local loads applied and the type of structure elements.

2.1.2 Particular case
When the global stress, in N/mm², calculated according to Ch 4, Sec 2 (excluding the cases of additional specific wave hull girder loads defined in Ch 3, Sec 2, [6]) is greater than 0.35 $R_y$, the global and local stresses are to be combined to check the scantlings of the structure elements contributing to the hull girder strength,

where: $R_y$ : As defined in Sec 2, [2.1.5] for steel structure and in Sec 2, [3.1.2] for aluminium structure.

As a rule, the following requirements are to be fully applied:
- NR467 Steel Ships, Part B, Chapter 7, dedicated to ships greater than 65 m in length, or
- Ch 4, App 2 of the present Rules.

For ship built in composite materials, a combination with the global hull girder stresses for the local scantling analysis may be carried out when deemed necessary by the Society, on a case-by-case basis.
Chapter 2

STRUCTURE DESIGN PRINCIPLES,
GENERAL ARRANGEMENT AND
SCANTLING CRITERIA

SECTION 1  STRUCTURE DESIGN PRINCIPLES
SECTION 2  SUBDIVISION, COMPARTMENT ARRANGEMENT, AND ARRANGEMENT OF HULL OPENINGS
SECTION 3  SCANTLING CRITERIA
**SECTION 1**  
**STRUCTURE DESIGN PRINCIPLES**

1 **General**

1.1 **Application**

1.1.1 **Steel structure**  
The requirements of the present Section apply to longitudinally or transversely framed structure arrangement of hulls 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.  

Additional specific structure design principles in relation to the service notation of the ship are defined in Ch 6, Sec 1.

1.1.2 **Aluminium structure**  
Equivalent arrangement for hulls built in aluminium alloys is defined in NR561 Aluminium Ships.

1.1.3 **Composite and plywood structure**  
Equivalent arrangement for hulls built in composite materials and/or plywood is defined in NR56 Composite Ships.

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 supporting members and secondary 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.  

The secondary 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 generally well rounded with smooth edges.

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 multihull platform**

2.2.1 Attention is to be paid to the structural continuity of the primary transverse cross structure of the platform ensuring the global transverse resistance of the multihull.  

The primary transverse cross structure of catamaran is generally to be continuous when crossing float structures.  

The connection between the transverse cross structures of swath and struts is to be examined by direct calculation.  

The general continuity principles defined in [2.1] apply also to the primary transverse cross structure of the platform.

2.3 **Insert plates and doublers**

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 Chapter 6.

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 according to the requirements in [2.3.2]. 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.

Any 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 Bottom structure arrangement

3.1 General arrangement

3.1.1 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 ship or the lifting by crane, when applicable. This check under such loading cases is not within the scope of classification.

3.1.2 Provision is to be made for the free passage of water from all the areas of the bottom to the suction, by means of scallops in floors and bottom girders.

3.1.3 Additional girders and floors may be fitted in the engine room to ensure adequate rigidity of the structure, according to the recommendations of the engine supplier.

3.1.4 If fitted, solid ballast is to be securely positioned. If necessary, intermediate girders and floors may be required. The builder is to check that the solid ballast material is compatible with the hull material.

3.1.5 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.

3.1.6 As a rule, bottom girders are to be fitted in way of each line of pillars. If it is not the case, local longitudinal members are to be provided.

3.2 Longitudinal framing arrangement of single bottom

3.2.1 As a general rule, hull with a longitudinally framed single bottom is to be fitted with a continuous or an inter-coastal centre girder welded to the floors.

3.2.2 Where side girders are fitted locally in lieu of the 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.

3.2.3 Centre and side bottom girders are to be extended as far as possible towards the ends of the hull.

3.2.4 Cut-outs fitted in the web of floors for the crossing of bottom longitudinals are to be taken into account for shear analysis of the floors.

3.3 Transverse framing arrangement of single bottom

3.3.1 Requirements of [3.1] apply also to transversally framed single bottom.

3.3.2 In general, the height, in m, of the floors at the centreline should not be less than B/16. In the case of ships with considerable rise of floors, this height may be required to be increased so as to ensure a satisfactory connection to the frames.

3.3.3 The ends of the floors at side are to be aligned with the side transverse members.

It may be accepted, on a case-by-case basis, that the floor ends at side be welded on a primary longitudinal member of the side shell or of the bottom.

3.3.4 Openings and cut-outs in the web of bottom girders for the crossing of floors are to be taken into account for shear analysis of the floors.

3.4 Double bottom arrangement

3.4.1 Double bottom height

As a general rule, the double bottom height is to be:

- sufficient to ensure access to any part of the bottom, and
- not less than 0.76 m in way of the centre girder.

3.4.2 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 this arrangement is not possible, suitable longitudinal structures such as partial girders, longitudinal brackets etc., fitted across the knuckle, are to be fitted.

3.4.3 Adequate continuity is to be provided between double bottom area and single bottom area.

3.4.4 Floors are to be fitted:

- watertight in way of the transverse watertight bulkheads
- reinforced in way of the double bottom steps.

3.4.5 Watertight floors are to be fitted with stiffeners having a section modulus not less than that required for tank bulkhead vertical stiffeners.

3.4.6 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 in Fig 1.
3.4.7 Double bottom compartment

Arrangement of the double bottom compartments is to be in accordance with Sec 2, [4].

3.4.8 Duct keel

Where a duct keel is arranged, the strength continuity of the structure of the floors is to be ensured.

3.5 Arrangement, scantlings and connections of bilge keels

3.5.1 Arrangement

Bilge keels may not be welded directly on the shell plating. An intermediate flat, or a doubler, is required on the shell plating.

The thickness of the intermediate flat is to be equal to the thickness of the bilge strake.

The ends of the bilge keels are to be snipped at an angle of 15° or rounded with a large radius. They are to be located in way of a bilge transverse stiffener. The ends of the intermediate flat are to be snipped at an angle of 15°.

The arrangement shown in Fig 2 is recommended.

The arrangement shown in Fig 3 may also be accepted.

3.5.2 Materials

The bilge keel and the intermediate flat are to be made of steel having the same yield stress and grade as the steel of the bilge strake.

3.5.3 Welding

Welding of the bilge keel with the intermediate flat is to be in accordance with Ch 7, Sec 2.

4 Side structure arrangement

4.1 General

4.1.1 In a transverse framing system, the side structure is made of secondary transverse frames, possibly supported by horizontal stringers.

4.1.2 In a longitudinal framing system, the side structure is made of secondary longitudinal stiffeners supported by vertical primary supporting members.

4.1.3 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.

4.2 Stiffener arrangement

4.2.1 In general, the section modulus of ‘tweendeck frames is to be not less than that required for the frames located immediately above.

4.2.2 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 4, Sec 6).

4.2.3 For transverse framing system, the attention of the Designer is drawn on the risk of buckling of the side shell plate panels in way of the frame ends. Extra-thickness or additional intercostal stiffeners may be requested in these areas on the side shell.
4.3 Openings in the side shell plating

4.3.1 Openings in the side shell are to be well rounded at the corners and located, as far as practicable, well clear of the superstructure ends.

4.3.2 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.

4.3.3 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.

4.3.4 The sea chest thickness is generally to be equal to the thickness of the local shell plating.

4.3.5 Openings for stabilizer fins are considered by the Society on a case-by-case basis.

5 Deck structure arrangement

5.1 General

5.1.1 Adequate continuity of decks (plates and stiffeners) is to be ensured in way of:
- stepped strength decks
- changes in the framing system
- large openings.

5.1.2 Deck supporting structures under cranes and windlass are to be adequately stiffened.

5.1.3 Pillars or other supporting structures are generally to be fitted under heavy concentrated loads on decks.

5.1.4 Stiffeners are also to be fitted in way of the ends and corners of deckhouses and partial superstructures.

5.1.5 Beams fitted at sides of a deck hatch are to be effectively supported by at least two deck girders located at each side of the deck opening.

5.2 Opening arrangement

5.2.1 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.

5.2.2 Extra thickness or additional reinforcements may be requested where deck openings are located:
- close to the primary transverse cross structure of the multihull platform
- in areas of deck structural singularity (cockpit, stepped deck, ...)
- in way of the fixing of out-fittings.

5.2.3 As a rule, all the deck openings are to be fitted with radiused corners. Generally, the corner radius is not to be less than 5% of the transverse width of the openings.

5.2.4 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.

5.3 Hatch supporting structures

5.3.1 Hatch side girders and hatch end beams of reinforced scantling are to be fitted in way of cargo hold openings.

In general, hatch end beams and deck transverses are to be in line with bottom and side transverse structures, so as to form a reinforced ring.

Adequate continuity of strength of longitudinal hatch coamings is to be ensured.

The details of connection of deck transverses with longitudinal girders and web frames are to be submitted to the Society for approval.

5.4 Pillar arrangement under deck

5.4.1 Pillars are to be connected to the inner bottom at the intersection of girders and floors and to any deck at the intersection of deck beams and deck girders.

Where it is not the case, an appropriate local structure is to be fitted to support the pillars.

5.4.2 Pillars are to be attached at their heads and heels by continuous welding.

Heads and heels of pillars are to be attached to the surrounding structure by means of brackets, insert plates or doubling plates so that the loads are well distributed.

In general, the thickness of the insert plates or doubling plates is to be not less than 1.5 times the thickness of the pillar.

5.4.3 If tensile stress is expected in the pillar, an insert plate is to be fitted in place of a doubling plate and head and heel brackets or equivalent arrangement are to be provided.

5.4.4 In tanks and in spaces intended for products able to procure explosive gases, solid or open section pillars are to be fitted.

5.4.5 Manholes may not be cut in the web of primary supporting structures in way of the heads and heels of pillars.

5.4.6 Tight or non-tight bulkheads may be considered as pillars, provided their scantlings comply with Ch 4, Sec 7.

5.4.7 The pillar scantlings are to comply with the requirements of Ch 4, Sec 7.

5.5 Deck structure in way of launching appliances used for survival craft or rescue boats

5.5.1 Attention is drawn on any possible specific requirements that could be issued by a Flag Administration with respect to local structure reinforcements in way of launching appliances used for survival craft or rescue boats.
6 Bulkhead structure arrangement

6.1 General

6.1.1 Plane 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.

6.1.2 As a general rule, the transverse bulkheads are to be stiffened, in way of bottom and deck girders, by vertical stiffeners in line with these girders or by any 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.

6.2 Watertight bulkheads

6.2.1 Crossing, through watertight transverse bulkheads, of bottom, side shell or deck longitudinal stiffeners is to be closed by watertight collar plates.

6.2.2 The 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.

6.2.3 The secondary stiffeners of watertight bulkheads in ‘tweendecks may be snipped at ends, provided their scantling is increased accordingly.

6.2.4 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.

6.3 Non-tight bulkheads

6.3.1 As a rule, non-tight bulkheads not acting as pillars are to be provided with vertical stiffeners having a maximum spacing equal to:

- 0,9 m, for transverse bulkheads
- two frame spacings, without exceeding 1,5 m, for longitudinal bulkheads.

6.3.2 Swash bulkheads

As a rule, the total area of the openings in swash bulkheads fitted in tanks is to be between 10% and 30% of the total area of the swash bulkhead.

6.4 Corrugated bulkheads

6.4.1 General

The main dimensions a, b, c, d and t of the corrugated bulkheads are defined in Fig 4.

Unless otherwise specified, the following requirement is to be complied with:

\[ a \leq 1,2 \, d \]

Moreover, in some cases, the Society may prescribe an upper limit for the ratio b / t.

In general, the bending internal radius \( R_i \), in mm, is to be not less than:

- for normal strength steel:
  \[ R_i = 2,5 \, t \]
- for high tensile steel:
  \[ R_i = 3,0 \, t \]

When welds, in a direction parallel to the bend axis, are provided in the zone of the bend, the welding procedures are to be submitted to the Society for approval, as a function of the importance of the structural element.

In general, where girders or vertical primary supporting members are fitted on corrugated bulkheads, they are to be arranged symmetrically.

6.4.2 Structural arrangement

Strength continuity of the corrugated bulkheads is to be ensured at the ends of the corrugations.

Where corrugated bulkheads are cut in way of primary supporting members, attention is to be paid to ensure correct alignment of the corrugations on each side of the primary supporting members.

The connection of the corrugated bulkheads with the deck and the bottom is to be carefully designed and specially considered by the Society.

In general, where vertically corrugated bulkheads are welded on the inner bottom:

- plate floors are to be fitted in way of the flanges of corrugations in the case of transverse bulkheads, and
- girders are to be fitted in way of the flanges of corrugations in the case of longitudinal bulkheads.
However, other arrangements ensuring adequate structural continuity may be accepted by the Society.

In general, the upper and lower parts of horizontally corrugated bulkheads are to be flat over a depth equal to 0.1 D.

Where stools are fitted at the lower part of transverse bulkheads, the thickness of the adjacent plate floors is to be not less than that of the stool plating.

6.4.3 Bulkhead stool

In general, plate diaphragms or web frames are to be fitted in bottom stools in way of the double bottom longitudinal girders or plate floors, as the case may be.

Brackets or deep webs are to be fitted to connect the upper stool to the deck transverses or hatch end beams, as the case may be.

The continuity of the corrugated bulkhead with the stool plating is to be adequately ensured. In particular, the upper strake of the lower stool is to be of the same thickness and yield stress as those of the lower strake of the bulkhead.

6.5 Bulkheads acting as pillars

6.5.1 As a rule, bulkheads acting as pillars (i.e. those designed to sustain the loads transmitted by a deck structure) are to be provided with vertical stiffeners spaced, at a maximum, two frames apart.

6.5.2 A vertical stiffening member is to be fitted on the bulkhead in line with the deck supporting member transferring the loads from the deck and is to be checked as defined in Ch 4, Sec 7.

6.6 Bracketed stiffeners

6.6.1 The bracket scantlings at ends of bulkhead stiffeners are to be defined 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 4, Sec 6.

7 Superstructures and deckhouses

7.1 Connection of superstructures and deckhouses with the hull structure

7.1.1 Superstructure and deckhouse frames are to be fitted, as far as practicable, in way of deck frame 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 superstructure ends, additional strengthening may be required.

7.1.2 Construction details

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.

7.1.3 Connection to the hull deck of the corners of superstructures and deckhouses is considered by the Society on a case-by-case basis. Where necessary, local reinforcements may be required.

7.1.4 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 rule, over at least three-frame spacings.

7.2 Structural arrangement of superstructures and deckhouses

7.2.1 Web frames, transverse partial bulkheads or other equivalent strengthening of each tier (superstructure and deckhouses) are to be arranged, where practicable, in line with the transverse reinforced structure below.

Web frames are also to be arranged in way of the 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 the deck transverses, at ends of superstructures and deckhouses.

7.2.2 Openings

The arrangement of superstructure and deckhouse openings is to be as defined in Ch 5, Sec 1.

The attention of the Shipowners, Shipyards and Designer is drawn on the fact that the Flag Administration may request the application of National Rules.

7.2.3 Access openings and doors

Access openings cut in side bulkheads 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 the 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.
SECTION 2 SUBDIVISION, COMPARTMENT ARRANGEMENT AND ARRANGEMENT OF HULL OPENINGS

Symbols

$L_{LL}$ : Load line length, in m, as defined in [2.1]
$FP_{LL}$ : Forward freeboard perpendicular. $FP_{LL}$ is to be taken at the forward end of $L_{LL}$ and is to coincide with the forward side of the stem on the waterline on which the length $L_{LL}$ is measured.

1 General

1.1 Application

1.1.1 The present Section is applicable to cargo ships and to non cargo ships as defined in Ch 1, Sec 1, [2.1.2], in accordance with the scope of application defined in Tab 1.

<table>
<thead>
<tr>
<th>Gross tonnage</th>
<th>&lt; 500 GT (1)</th>
<th>≥ 500 GT (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subdivision arrangement</td>
<td>NR566</td>
<td>[3]</td>
</tr>
<tr>
<td>Compartment arrangement</td>
<td>NR566</td>
<td>[4]</td>
</tr>
<tr>
<td>Access arrangement</td>
<td>[5]</td>
<td>[5]</td>
</tr>
<tr>
<td>Hull opening arrangement</td>
<td>NR566</td>
<td>NR467</td>
</tr>
</tbody>
</table>

(1) Except ships with one of the following service notations:
- passenger ship with unrestricted navigation
- ro-ro passenger ship with unrestricted navigation
- fishing vessel
- chemical tanker.

(2) And ships with one of the service notations defined in (1), whatever their tonnage.

1.1.2 Additional specific arrangement

Additional specific arrangement in relation to the service notation of the ship are defined in Ch 6, Sec 1.

1.1.3 Openings in superstructures and deckhouses

Arrangement of openings in superstructures and deckhouses are defined in Ch 5, Sec 1.

2 Definition

2.1 Load line length $L_{LL}$

2.1.1 The load line length $L_{LL}$ is the distance, in m, on the waterline at 85% of the least moulded depth from the top of the keel, measured from the forward side of the stem to the centre of the rudder stock. $L_{LL}$ is to be not less than 96% of the total length on the same waterline.

In ship design with a rake of keel, the waterline on which this length is measured is parallel to the designed waterline at 85% of the least moulded depth $D_{min}$ found by drawing a line parallel to the keel line of the ship (including skeg) tangent to the moulded sheer line of the freeboard deck. The least moulded depth is the vertical distance measured from the top of the keel to the top of the freeboard deck beam at side at the point of tangency (see Fig 1).

Figure 1: $L_{LL}$ of ships with a rake of keel

2.2 Machinery spaces of category A

2.2.1 Machinery spaces of category A are those spaces or trunks to such spaces which contain:
- internal combustion machinery used for main propulsion, or
- internal combustion machinery used for purposes other than propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or
- any oil fired boiler or fuel oil unit.

3 Subdivision arrangement

3.1 Number of transverse watertight bulkheads

3.1.1 General

All ships, in addition to complying with the requirements of [3.1.2], are to have at least the following transverse watertight bulkheads:
- one collision bulkhead
- one after peak bulkhead for ships having the service notation passenger ship or ro-ro passenger ship
- two bulkheads forming the boundaries of the machinery space for ships with machinery amidships, or one bulkhead forward of the machinery space for ships with machinery aft. In the case of ships with an electrical propulsion plant, both the generator room and the engine room are to be enclosed by watertight bulkheads.
3.1.2 Additional bulkheads

As a rule, for ships not required to comply with subdivision regulations, the number of transverse bulkheads adequately spaced are to be at least as indicated in Tab. 2.

Additional bulkheads may be required for ships having to comply with subdivision or damage stability criteria.

Table 2: Number of transverse bulkheads

<table>
<thead>
<tr>
<th>Ship length, in m</th>
<th>For ships with aft machinery</th>
<th>For the other ships</th>
</tr>
</thead>
<tbody>
<tr>
<td>L &lt; 65</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>L ≥ 65</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

3.2 Water ingress detection

3.2.1 General

When a ship is fitted, below the freeboard deck, with a single cargo hold or with cargo holds not separated by at least one bulkhead made watertight up to the freeboard deck, a water ingress detection system is to be fitted according to NR467 Steel Ships, Pt C, Ch 1, Sec 10, [6.12.2].

3.2.2 Bulk carriers

For ships granted with the service notation bulk carrier, bulk carrier ESP, ore carrier ESP, combination carrier/OBO ESP or combination carrier/OOC ESP, the water ingress detection system is to be fitted according to NR467 Steel Ships, Pt C, Ch 1, Sec 10, [6.12.1].

3.3 Collision bulkhead

3.3.1 A collision bulkhead, made watertight up to the bulkhead deck, is to be fitted. This bulkhead is to be located at a distance from FPIL not less than 5 per cent of the length LLL and, except as may be permitted by the Society, not more than 8 per cent of LLL or 5 per cent of LLL + 3 m, whichever is the greater.

Note 1: For ships not covered by the SOLAS Convention, LLL need not be taken less than 50 m, unless otherwise required by the National Authorities.

3.3.2 Where any part of the ship below the waterline extends forward of the forward perpendicular, e.g. a bulbous bow, the distances, in metres, stipulated in [3.3.1] are to be measured from a point located either:

- at mid-length of such an extension, or
- at a distance equal to 1.5 per cent of the length LLL forward of the forward perpendicular.

3.3.3 The bulkhead may have steps or recesses, provided they are within the limits specified in [3.3.1] or [3.3.2].

No door, manhole, ventilation duct or any other opening is to be fitted in the collision bulkhead below the bulkhead deck.

3.3.4 At the Owner’s request and subject to the agreement of the flag Administration, the Society may accept, on a case-by-case basis, a distance from the collision bulkhead to the forward perpendicular FPIL greater than the maximum limit specified in [3.3.1] and [3.3.2], provided that subdivision and stability calculations show that, when the ship is in upright condition on full load summer waterline, flooding of the space forward of the collision bulkhead will not result in any part of the freeboard deck becoming immersed, or in any unacceptable loss of stability.

In such a case, the attention of the Owner and the Shipyard is drawn to the fact that the flag Administration may impose additional requirements and that such an arrangement is, in principle, formalised by the issuance of a certificate of exemption under the SOLAS Convention provisions. Moreover, in case of change of flag, the taking Administration may not accept the exemption.

3.3.5 Where a long forward superstructure is fitted, the collision bulkhead is to be extended weathertight up to the next deck above the bulkhead deck. This extension need not be fitted directly above the bulkhead below, provided that:

- it is located within the limits specified in [3.3.1] or [3.3.2], considering the exemption given in [3.3.6], and
- the part of the deck which forms the step is made effectively weathertight.

3.3.6 Where bow doors are fitted and a sloping loading ramp forms part of the extension of the collision bulkhead above the freeboard deck, the part of the ramp beyond 2.3 m above the freeboard deck may extend forward of the limit specified in [3.3.1] or [3.3.2]. The ramp is to be weathertight over its full length.

3.3.7 The number of openings in the extension of the collision bulkhead above the freeboard deck is to be restricted to the minimum compatible with the design and normal operation of the ship. All such openings are to be capable of being closed weathertight.

3.4 After peak bulkheads, machinery space bulkheads and stern tubes

3.4.1 General

Bulkheads are to be fitted to separate the machinery space from the cargo and accommodation spaces forward and aft, and made watertight up to the bulkhead deck. In passenger ships, an after peak bulkhead is also to be fitted and made watertight up to the bulkhead deck. The after peak bulkhead may, however, be stepped below the bulkhead deck, provided the degree of safety of the ship as regards subdivision is not thereby impaired.

3.4.2 Sterntubes

In all the cases, stern tubes are to be enclosed in watertight spaces of moderate volume. In passenger ships, the stern gland is to be located in a watertight shaft tunnel or other watertight space separate from the stern tube compartment and of such a volume that, if flooded by leakage through the stern gland, the bulkhead deck will not be immersed. In cargo ships, other measures to minimise the danger of seawater ingress in case of damage to the stern tube arrangement may be taken at the discretion of the Society.
3.5 Height of transverse watertight bulkheads other than collision bulkhead and after peak bulkheads

3.5.1 Transverse watertight bulkheads are to extend watertight up to the bulkhead deck. In exceptional cases and at the Owner’s request, the Society may allow transverse watertight bulkheads to terminate at a deck below the freeboard deck, provided that deck is at an adequate distance above the full load summer waterline.

3.5.2 Where it is not practicable to arrange a watertight bulkhead in one plane, a stepped bulkhead may be fitted. In this case, the part of the deck which forms the step is to be watertight and equivalent in strength to the bulkhead.

3.6 Openings in watertight bulkheads and decks - Ships with service notation other than passenger ship or ro-ro passenger ship

3.6.1 The requirements from [3.6.2] to [3.6.10] apply to ships having a service notation other than passenger ship or ro-ro passenger ship.

The openings in watertight bulkheads below the bulkhead deck of ships having the service notation passenger ship or ro-ro passenger ship are to comply with NR467 Steel Ships, respectively Part D, Chapter 11 and Part D, Chapter 12.

3.6.2 The number of openings in watertight subdivisions is to be kept to a minimum compatible with the design and proper working of the ship. Where penetrations of watertight bulkheads and internal decks are necessary for access, piping, ventilation, electrical cables, etc., arrangement is to be made to maintain the watertight integrity. The Society may permit relaxation in the watertightness of openings above the freeboard deck, provided it is demonstrated that any progressive flooding can be easily controlled and that the safety of the ship is not impaired.

3.6.3 No door, manhole ventilation duct or any other opening is permitted in the collision bulkhead below the subdivision deck.

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

3.6.5 Valves not forming part of a piping system are not permitted in watertight subdivision bulkheads.

3.6.6 The requirements relevant to the degree of tightness, as well as the operating systems, for doors or other closing appliances complying with the provisions from [3.6.7] to [3.6.10], are specified in Tab 3.

3.6.7 Openings used while at sea

Doors provided to ensure the watertight integrity of internal openings which are used while at sea are to be sliding watertight doors capable of being remotely closed from the bridge and are also to be operable locally from each side of the bulkhead. Indicators are to be provided at the control position showing whether the doors are open or closed, and an audible alarm is to be provided at the door closure. The power, control and indicators are to be operable in the event of main power failure. Particular attention is to be paid to minimise the effect of control system failure. Each power-operated sliding watertight door is to be provided with an individually hand-operated mechanism. The possibility of opening and closing the door by hand at the door itself from both sides is to be assured.

Table 3 : Doors in watertight subdivision bulkheads

<table>
<thead>
<tr>
<th>Doors</th>
<th>Sliding type</th>
<th>Hinged type</th>
<th>Rolling type (cargo between deck spaces)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watertight below the freeboard deck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open at sea</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normally closed (2)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Remained closed (2)</td>
<td>X (3) (4)</td>
<td>X (3) (4)</td>
<td></td>
</tr>
<tr>
<td>Weathertight / watertight (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above the freeboard deck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open at sea</td>
<td>X</td>
<td>X (3) (4)</td>
<td></td>
</tr>
<tr>
<td>Normally closed (2)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Remained closed (2)</td>
<td></td>
<td>X (3) (4)</td>
<td></td>
</tr>
</tbody>
</table>

(1) Watertight doors are required when they are located below the waterline at the equilibrium of the final stage of flooding; otherwise a weathertight door is accepted.
(2) The following notice is to be affixed on both sides of the door: “To be kept closed at sea”.
(3) The door is to be closed before the voyage commences.
(4) If the door is accessible during the voyage, a device preventing non-authorised opening is to be fitted.
3.6.8 Openings normally closed at sea
Access doors and access hatch covers normally closed at sea and intended to ensure the watertight integrity of internal openings are to be provided with means of indication, locally and on the bridge, showing whether these doors or hatch covers are open or closed. A notice is to be affixed to each such door or hatch cover to the effect that it is not to be left open.

3.6.9 Doors or ramps in large cargo spaces
Watertight doors or ramps of satisfactory construction may be fitted to internally subdivide large cargo spaces, provided that the Society is satisfied that such doors or ramps are essential. These doors or ramps may be hinged, rolling or sliding doors or ramps, but are not to be remotely controlled. Such doors are to be closed before the voyage commences and are to be kept closed during navigation. Should any of the doors or ramps be accessible during the voyage, they are to be fitted with a device preventing unauthorised opening.

The word “satisfactory” means that the scantlings and sealing requirements for such doors or ramps are to be sufficient to withstand the maximum head of water at the flooded waterline.

3.6.10 Openings kept permanently closed at sea
Other closing appliances which are kept permanently closed at sea to ensure the watertight integrity of internal openings are to be provided with a notice affixed to each such closing appliance to the effect that it is to be kept closed at sea. Manholes fitted with closely bolted covers need not be so marked.

4 Compartment arrangement

4.1 Definitions

4.1.1 Cofferdam
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.

4.2 Cofferdam arrangement

4.2.1 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.

4.2.2 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 common boundary plate thickness of the adjacent tanks is increased, with respect to the thickness obtained according to Ch 4, Sec 3, 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 7, Sec 3.

4.3 Double bottom

4.3.1 Except for ships with service notation fishing vessel, a double bottom is to be fitted extending from the collision bulkhead to the after peak bulkhead, as far as this is practicable and compatible with the design and proper working of the ship.

4.3.2 Any part of a ship which is not fitted with a double bottom is to be capable of withstanding bottom damages as specified in NR467 Steel Ships, Pt B, Ch 3, Sec 3, [3.4].

4.3.3 Where a double bottom is required to be fitted, the inner bottom is to be continued out to the ship sides in such a manner as to protect the bottom to the turn of the bilge. Such protection is to be deemed satisfactory if the inner bottom, at any part, is not lower than a plane parallel to the keel line and located at a vertical distance h, measured from the keel line, not less than, in m:

\[ h = \frac{B}{20} \] without being less than 0.760 m.

However, h need not be taken greater than 2 m.
4.3.4 Small wells constructed in the double bottom in connection with the drainage arrangement of holds are not to extend downward more than necessary. A well extending to the outer bottom is, however, permitted at the after end of the shaft tunnel of the ship. Other wells may be permitted by the Society if it is satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with [4.3]. In no case the vertical distance from the bottom of such a well to a plane coinciding with the keel line is to be less than 500 mm.

4.3.5 Additional requirements for passenger ships and tankers

Special requirements for passenger ships and tankers are specified in NR467 Steel Ships, Pt D, Ch 12, Sec 2 and in Pt D, Ch 7, Sec 2.

4.3.6 Additional requirements for oil tankers

Double bottom requirements for oil tankers with regard to fire prevention and pollution prevention are defined in NR467 Steel ships, Pt D, Ch 7, Sec 2.

4.4 Compartments forward of the collision bulkhead

4.4.1 The fore peak and other compartments located forward of the collision bulkhead are not to be used for the carriage of fuel oil or other flammable products.

4.5 Minimum bow height

4.5.1 The minimum bow height \( F_b \) is to be as defined in NR566, Ch 1, Sec 4 or NR467 Steel Ships, Part B, Ch 2, Sec 2 for ships greater than 500 GT.

4.6 Shaft tunnels

4.6.1 Shaft tunnels are to be watertight.

4.7 Watertight ventilators and trunks

4.7.1 Watertight ventilators and trunks are to be carried at least up to:

- the freeboard deck for ships other than passenger ships
- the bulkhead deck for passenger ships.

4.8 Fuel oil tanks

4.8.1 The arrangements for the storage, distribution and utilisation of the fuel oil are to be such as to ensure the safety of the ship and persons on board.

4.8.2 As far as practicable, fuel oil tanks are to be part of the ship structure and are to be located outside the 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
- they are 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 located within the boundaries of machinery spaces of category A, they may not contain fuel oil having a flashpoint less than 60°C.

4.8.3 Fuel oil tanks may not be located where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces.

Precautions are to be taken to prevent any oil that may escape under pressure from any pump, filter or heater from coming into contact with heated surfaces.

Fuel oil tanks in boiler spaces may not be located immediately above the boilers or in areas subjected to high temperatures, unless special arrangements are provided in agreement with the Society.

4.8.4 Where a compartment intended for goods or coal is located close to a heated liquid container, a suitable thermal insulation is to be provided.

4.8.5 Fuel oil tank protection

All ships with an aggregate oil fuel capacity of 600 m\(^3\) are to comply with the requirements of Regulation 12 A of Annex I to Marpol Convention, as amended.

5 Access arrangement

5.1 General

5.1.1 The number and size of small hatchways for trimming and access openings to tanks or other enclosed spaces are to be kept to the minimum consistent with the access and maintenance of the space.

5.2 Double bottom

5.2.1 Manholes are to be provided in floors and girders so as to provide convenient access to any part of the double bottom.

5.2.2 Manholes may not be cut in the continuous centre-line girder or in the floors and girders below pillars, except where allowed by the Society, on a case-by-case basis.

5.2.3 Inner bottom manholes are to be not smaller than 400 mm x 400 mm. Their number and location are to be so arranged as to provide convenient access to any part of the double bottom.
5.2.4 However, the size of manholes and lightening holes in floors and girders is, in general, to be less than 50 per cent of the local height of the double bottom. Where manholes of greater size are needed, edge reinforcement by means of flat bar rings or other suitable stiffeners may be required.

5.2.5 Inner bottom manholes are to be closed by watertight plate covers. Doubling plates are to be fitted on the covers, where secured by bolts. Where no ceiling is fitted, covers are to be adequately protected from damage caused by the cargo.

5.3 Access arrangement to, and within, spaces in, and forward of, the cargo area

5.3.1 General
The requirements defined in [5.3.2] for access to tanks, in [5.3.3] for access within tanks and in [5.3.4] for construction of ladders are not applicable to:
- ships with service notation oil tanker ESP (see NR467 Steel Ships, Part D, Chapter 7)
- spaces in double bottom and double side tanks.

Additional specific requirements, defined in NR467 Steel Ships, Part D, are applicable to the following service notations:
- livestock carrier: see NR467, Part D, Chapter 3
- bulk carrier: see NR467, Part D, Chapter 4
- ore carrier: see NR467, Part D, Chapter 5
- combination carrier: see NR467, Part D, Chapter 6
- oil tanker: see NR467, Part D, Chapter 7
- chemical tanker: see NR467, Part D, Chapter 8
- passenger ships: see NR467, Part D, Chapter 11
- ro-ro passenger ship: see NR467, Part D, Chapter 12.
- tugs: see NR467, Part E, Chapter 1
- supply vessels: see NR467, Part E, Chapter 3
- oil recovery ships: see NR467, Part E, Chapter 5
- diving support vessels: see NR467, Part E, Chapter 7
- standby rescue vessels: see NR467, Part E, Chapter 10

5.3.2 Access to tanks
Tanks and subdivisions of tanks having lengths of 35 m and above are to be fitted with at least two access hatchways and ladders, as far apart as practicable longitudinally. Tanks less than 35 m in length are to be served by at least one access hatchway and ladder. The dimensions of any access hatchway are to be sufficient to allow a person wearing a self-contained breathing apparatus to ascend or descend the ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the tank. In no case is the clear opening to be less than 600 mm x 600 mm.

When a tank is subdivided by one or more swash bulkheads, at least two hatchways are to be fitted, and these hatchways are to be so located that the associated ladders effectively serve all subdivisions of the tank.

5.3.3 Access within tanks
Where one or more swash bulkheads are fitted in a tank, they are to be provided with openings not less than 600 mm x 800 mm and so arranged as to facilitate the access of persons wearing a breathing apparatus or carrying a stretcher with a patient.

To provide ease of movement on the tank bottom throughout the length and breadth of the tank, a passageway is to be fitted on the upper part of the bottom structure of each tank or, alternatively, manholes having at least the dimensions of 600 mm x 800 mm are to be arranged in the floors at a height of not more than 600 mm from the bottom shell plating.

The passageways located in the tanks are to be as follows:

a) They are to have a minimum width of 600 mm, considering the requirement for the possibility of carrying an unconscious person. Elevated passageways are to be provided with guard rails over their entire length. Where guard rails are provided on one side only, foot rails are to be fitted on the opposite side. Shelves and platforms forming a part of the access to the tanks are to be of non-skid construction, where practicable, and be fitted with guard rails. Guard rails are to be fitted to bulkhead and side stringers when such structures are being used for recognised access.

b) Access to elevated passageways from the ship bottom is to be provided by means of easily accessible passageways, ladders or treads. Treads are to provide lateral support for the foot. Where rungs of ladders are fitted against a vertical surface, the distance from the centre of the rungs to that surface is to be at least 150 mm.

c) When the height of the bottom structure does not exceed 1,50 m, the passageways required in a) may be replaced by alternative arrangements having regard to the bottom structure and requirement for ease of access of a person wearing a self-contained breathing apparatus or carrying a stretcher with a patient.

Where manholes are fitted, as indicated in [5.2.4], access is to be facilitated by means of steps and hand grips with platform landings on each side.

Guard rails are to be 900 mm in height and consist of a rail and intermediate bar. These guard rails are to be of substantial construction.

5.3.4 Construction of ladders
In general, the ladders are not to be inclined at an angle exceeding 70°. The flights of ladders are not to be more than 9 m in actual length. Resting platforms of adequate dimensions are to be provided.

Ladders and handrails are to be constructed of steel of adequate strength and stiffness and securely attached to the tank structure by stays. The method of support and length of stay are to be such that vibration is reduced to a practical minimum.

 Provision is to be made for maintaining the structural strength of the ladders and railings taking into account the corrosive effect of the cargo.

As a rule, the width of ladders between stringers should not be less than 400 mm.
The treads are to be equally spaced at a distance apart measured vertically not exceeding 300 mm. They are to be formed of two square steel bars of not less than 22 mm by 22 mm in section fitted to form a horizontal step with the edges pointing upward, or of equivalent construction. The treads are to be carried through the side stringers and attached thereto by double continuous welding.

All sloping ladders are to be provided with handrails of substantial construction on both sides, fitted at a convenient distance above the treads.

5.4 Shaft tunnels

5.4.1 Tunnels are to be large enough to ensure easy access to shafting.

5.4.2 Access to the tunnel is to be provided by a watertight door fitted on the aft bulkhead of the engine room in compliance with [3.6], and an escape trunk which can also act as watertight ventilator is to be fitted up to the subdivision deck, for tunnels greater than 7 m in length.

5.5 Access to steering gear compartment

5.5.1 The steering gear compartment is to be readily accessible and, as far as practicable, separated from machinery spaces. Suitable arrangements to ensure working access to steering gear machinery and controls are to be provided. 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.
SECTION 3  SCANTLING CRITERIA

Symbols

\( R \) : Minimum yield stress, in N/mm\(^2\) to be taken equal to:
- for steel structures: \( R_y \) as defined in Ch 1, Sec 2, [2.1.5]
- for aluminium structures: \( R_y \) as defined in Ch 1, Sec 2, [3.1.2].

1 General

1.1 Application

The requirements of the present Section define:
- the permissible stresses considered for the check of steel and aluminium structures
- the permissible safety factors considered for the check of composite structures.

1.2 Global and local stresses

1.2.1 General

As a rule, the global hull girder stresses and the local stresses are examined independently.
However, according to the global stress level, the hull structure under local stresses may be checked taking into account the global hull girder stresses (see Ch 1, Sec 3, [2.1.2]).
When a three-dimensional model, simultaneously loaded by global external loads and local loads, is submitted to the Society by the designer, the checking criteria are to be in accordance with [2.3].

1.3 Stress notation

1.3.1 As a rule, the notations used for the stresses are:

\( \sigma \) : Bending, compression or tensile stress
\( \tau \) : Shear stress.

The following indexes are used depending on the type of stress considered:

- \( a_m \) : Rule permissible stress value
- \( gl \) : Stresses resulting from a global strength analysis as defined in Ch 4, Sec 2
- \( loc \) : Stresses resulting from a local strength analysis as defined from Ch 4, Sec 3 to Ch 4, Sec 5
- \( VM \) : Combined stress calculated according to the Von Mises criteria.

2 Steel and aluminium alloy structures

2.1 Permissible stresses under global loads

2.1.1 When the global hull girder strength is examined as required in Ch 4, Sec 2, [1.1.3], the permissible global stresses for plating and for secondary and primary stiffeners, and the safety factors for the buckling check of the structure submitted to global loads are defined in Tab 1.

<table>
<thead>
<tr>
<th>Structure element</th>
<th>Stress and safety factor</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Steel</td>
</tr>
<tr>
<td>Plating</td>
<td>( \sigma_{glam} (1) )</td>
<td>0.60 ( R )</td>
</tr>
<tr>
<td>Secondary stiffeners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary stiffeners</td>
<td>( \tau_{glam} (1) )</td>
<td>0.40 ( R )</td>
</tr>
<tr>
<td>Plating</td>
<td>( SF_{buck} (2) )</td>
<td>1.35</td>
</tr>
<tr>
<td>Secondary stiffeners</td>
<td>( SF_{buck} (2) )</td>
<td>1.45</td>
</tr>
<tr>
<td>Primary stiffeners</td>
<td>( SF_{buck} (2) )</td>
<td>1.25</td>
</tr>
</tbody>
</table>

(1) Permissible stresses may be increased by 15% for:
- planing hull when the actual global stresses are calculated with the moment in planing mode defined in Ch 3, Sec 2, [6.1]
- swath when the actual global stresses are calculated with the moment acting on twin hull defined in Ch 3, Sec 2, [6.2.2]
(2) Permissible buckling safety factor may be decreased by 15% for:
- planing hull when the actual global stresses are calculated with the moment in planing mode defined in Ch 3, Sec 2, [6.1]
- swath when the actual global stresses are calculated with the moment acting on twin hull defined in Ch 3, Sec 2, [6.2.2].
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 of structure element and the type of local loads, are defined in Tab 2 and Tab 3.

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 structure element and the type of local loads, is to be carried out taking into account the following permissible stresses:

- for analysis through an isolated beam calculation: \( \sigma_{\text{locam}} \) and \( \tau_{\text{locam}} \)
- for analysis through a three-dimensional structure beam or a finite element model: \( \sigma_{\text{vmax}} \)

where:

\( \sigma_{\text{locam}}, \tau_{\text{locam}} \): Permissible local stresses, in N/mm², defined in Tab 4

\( \sigma_{\text{vmax}} \): Permissible local Von Mises equivalent stresses, in N/mm², defined in Tab 4.

When a finite element model is used, the typical mesh size is to be equal to the secondary stiffener spacing.

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:
- for primary stiffeners not contributing to the global strength and calculated with external sea pressures, internal loads or flooding loads:
  \( \sigma_c \geq SF_{\text{buck}} (\sigma_{ac} + 0,1 R) \)
- for primary stiffeners contributing to the global strength and calculated with external sea pressures, internal loads or flooding loads:
  \( \sigma_c \geq SF_{\text{buck}} (\sigma_{ac} + 0,35 R) \)
- for the other cases:
  \( \sigma_c \geq SF_{\text{buck}} \sigma_{ac} \)

where:

\( \sigma_c \): Critical buckling stress of the attached plating as defined in Ch 4, App 1, [2]

\( \sigma_{ac} \): Actual compressive stress in the attached plating induced by the local loads

\( SF_{\text{buck}} \): Safety factor defined in Tab 4.

Table 2: Permissible local stresses \( \sigma_{\text{locam}} \) for plating under local loads

<table>
<thead>
<tr>
<th>Loading case</th>
<th>Plating</th>
<th>Framing</th>
<th>Permissible value of ( \sigma_{\text{locam}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>for steel structure</td>
</tr>
<tr>
<td>Local sea and internal pressures</td>
<td>Plating not contributing to the global strength</td>
<td>transverse</td>
<td>0,70 R</td>
</tr>
<tr>
<td></td>
<td>Plating contributing to the global strength</td>
<td>longitudinal</td>
<td>0,50 R</td>
</tr>
<tr>
<td>Local dynamic sea pressures (bottom slamming for planing hull, or bottom impact pressure for flat bottom forward area, or side shell impact)</td>
<td>All type of plating</td>
<td>transverse</td>
<td>0,75 R</td>
</tr>
<tr>
<td></td>
<td>Flat forward bottom plating</td>
<td>longitudinal</td>
<td>0,90 R</td>
</tr>
<tr>
<td>Flooding loads</td>
<td>Plating not contributing to the global strength</td>
<td>transverse</td>
<td>0,75 R</td>
</tr>
<tr>
<td></td>
<td>Plating contributing to the global strength</td>
<td>longitudinal</td>
<td>0,85 R</td>
</tr>
<tr>
<td></td>
<td>Collision bulkhead</td>
<td>all type of framing</td>
<td>0,70 R</td>
</tr>
<tr>
<td>Testing loads</td>
<td>All type of plating</td>
<td>all type of framing</td>
<td>0,85 R</td>
</tr>
</tbody>
</table>

Note 1: The platings contributing to the global strength are the continuous platings located between 0,3 L and 0,7 L and the continuous platings located in the platform of multihull.
Table 3: Permissible local stresses for secondary stiffeners under local loads

<table>
<thead>
<tr>
<th>Loading case</th>
<th>Structure element</th>
<th>Stress</th>
<th>Permissible value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local sea and internal pressures</td>
<td>Stiffeners contributing to the global strength</td>
<td>$\sigma_{locam}$</td>
<td>0.55 R</td>
</tr>
<tr>
<td></td>
<td>Stiffeners not contributing to the global strength</td>
<td>$\sigma_{locam}$</td>
<td>0.80 R</td>
</tr>
<tr>
<td></td>
<td>All stiffeners</td>
<td>$\tau_{locam}$</td>
<td>0.45 R</td>
</tr>
<tr>
<td>Local dynamic sea pressures (bottom slamming for planing hull, or bottom impact pressure for flat bottom forward area, or side shell impact)</td>
<td>All stiffeners</td>
<td>$\sigma_{locam}$</td>
<td>0.75 R</td>
</tr>
<tr>
<td></td>
<td>Flat forward bottom stiffeners</td>
<td>$\tau_{locam}$</td>
<td>0.50 R</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\sigma_{locam}$</td>
<td>0.90 R</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\tau_{locam}$</td>
<td>0.55 R</td>
</tr>
<tr>
<td>Flooding loads</td>
<td>Stiffeners contributing to the global strength</td>
<td>$\sigma_{locam}$</td>
<td>0.60 R</td>
</tr>
<tr>
<td></td>
<td>Stiffeners not contributing to the global strength</td>
<td>$\sigma_{locam}$</td>
<td>0.85 R</td>
</tr>
<tr>
<td></td>
<td>All stiffeners</td>
<td>$\tau_{locam}$</td>
<td>0.45 R</td>
</tr>
<tr>
<td></td>
<td>Stiffeners on collision bulkhead</td>
<td>$\sigma_{locam}$</td>
<td>0.65 R</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\tau_{locam}$</td>
<td>0.40 R</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\sigma_{locam}$</td>
<td>0.85 R</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\tau_{locam}$</td>
<td>0.50 R</td>
</tr>
<tr>
<td>Testing loads</td>
<td>All stiffeners</td>
<td>$\sigma_{locam}$</td>
<td>0.85 R</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\tau_{locam}$</td>
<td>0.50 R</td>
</tr>
</tbody>
</table>

Note 1: In this Table, “stiffeners” means “secondary stiffeners”.

Note 2: The stiffeners contributing to the global strength are the continuous longitudinal stiffeners located between 0.3 L and 0.7 L and the continuous transverse stiffeners located in the platform of multihull.

Table 4: Permissible local stresses for primary stiffeners under local loads

<table>
<thead>
<tr>
<th>Loading case</th>
<th>Structure element</th>
<th>Stress / Safety factor</th>
<th>Permissible value</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>Local dynamic sea pressures (bottom slamming for planing hull, or bottom impact pressure for flat bottom forward area)</td>
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Note 1: The primary stiffeners contributing to the global strength are the continuous primary stiffeners located between 0.3 L and 0.7 L and the continuous transverse primary stiffeners located in the platform of multihull.
2.3 Permissible stresses of primary stiffeners under global and local loads

2.3.1 General

The requirements of this Article apply to the structure check of primary stiffeners analysed through a three-dimensional structural beam or a finite element model, loaded simultaneously by global loads (as defined in Ch 3, Sec 2, [4] and Ch 3, Sec 2, [5]) and by local loads induced by external sea pressures and internal loads (as defined in Ch 3, Sec 3, [2] and Ch 3, Sec 3, [3]).

As a rule, the dynamic loads defined in Ch 3, Sec 3, [3], the testing loads defined in Ch 3, Sec 4, [5] and the flooding loads defined in Ch 3, Sec 4, [6] need not be taken into account when local and global loads are combined.

2.3.2 Checking criteria

It is to be checked that the stresses deduced from the model are in compliance with the following criteria:

\[ \sigma_{VM} \leq \frac{R}{SF} \]

\[ \sigma \leq \frac{\sigma_c}{SF_{buck}} \]

where:

- \( \sigma_{VM} \): Von Mises equivalent stresses, in N/mm², deduced from the model
- \( \sigma_c \): Critical buckling stresses of the attached plating, in N/mm², calculated as defined in Ch 4, App 1, [2]
- \( \sigma \): Actual compressive stress in the attached plating, in N/mm², deduced from the model calculation
- \( SF \): Safety factor to be taken equal to 1.25
- \( SF_{buck} \): Safety factor defined in Tab 4.

Finite Element Model analyses are examined by the Society on a case by case and on the basis of the requirements defined in NR467 Steel Ships, Part B, Ch 7, Sec 3 [4.4].

3 Composite material structure

3.1 General

3.1.1 Principle of design review

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:
  \[ \frac{\sigma_{bri}}{\sigma_{app}} \geq SF \]

- Critical buckling stress criteria:
  \[ \frac{\sigma_c}{\sigma_{app}} \geq SF \]

- Combined stress criteria in layers:
  \[ SF_{CS} \geq SF_{CS_{app}} \]

where:

- \( \sigma_{bri} \): In-plane theoretical individual layer breaking stresses defined in NR546 Composite Ships, Sec 5, [5]
- \( \sigma_c \): Critical buckling stress of the composite element considered calculated as defined in NR546, Composite Ships, Sec 6 [4].
- \( \sigma_{app} \): In-plane individual layer applied stresses
- \( \sigma_{app} \): Compressive stress applied to the whole laminate considered

\( SF, SF_{b}, SF_{CS}, SF_{CS_{app}} \): Rule safety factors defined in [3.2.3]

SF_{CS_{app}}: Actual combined stress applied in layer as calculated in NR546 Composite ships, Sec 2, [1.3.3].

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

3.1.2 Types of stress considered

The following different types of stress are considered, corresponding to the different loading modes of the fibres:

a) Principal stresses in the individual layers

- Stress \( \sigma_1 \)
  These stresses, parallel to the fibre (longitudinal direction), may be tensile or compressive stresses and are mostly located as follows:
  - in 0° direction of unidirectional tape or fabric reinforcement systems
  - in 0° and 90° directions of woven roving

- Stress \( \sigma_2 \)
  These stresses, perpendicular to the fibre (transverse direction), may be tensile or compressive stresses and are mostly located as follows:
  - in 90° direction of unidirectional tape or combined fabrics when the fibres of the set are stitched together without criss-crossing

- Shear stress \( \tau_{12} \) (in the laminate plane)
  These shear stresses, parallel to the fibre, may be found in all type of reinforcement systems

- Shear stresses \( \tau_{13} \) and \( \tau_{23} \) (through the laminate thickness)
  These shear stresses, parallel or perpendicular to the fibre, are the same stresses than the interlaminar shear stresses \( \tau_{32} \) and \( \tau_{31} \)

- Combined stress (Hoffman criteria)

b) Stresses in the whole laminate

- Compressive and shear stresses in the whole laminate inducing buckling.
3.1.3 Theoretical breaking criteria
Three theoretical breaking criteria are used in the present Rules:

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

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

c) the critical buckling stress criteria applied to the laminate. The theoretical breaking criteria defined in items a) and b) are to be checked for each individual layer.

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

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

3.2 Rule safety factors

3.2.1 General

a) General consideration:

The rule safety factors to be considered for the composite structure check are defined in [3.2.3], according to the partial safety factors defined in [3.2.2].

b) Additional considerations:

Rule safety factors other than those defined in [3.2.3] may be accepted for one elementary layer when the full lay-up laminate exhibits a sufficient safety margin between the theoretical breaking stress of this elementary layer and the theoretical breaking stress of the other elementary layers.

Finite Element Model analyses are examined on a case by case basis by the Society. As a rule, when the structure is checked with a Finite Element Model, the rule safety factors defined in [3.2.3] and [3.2.4] may be reduced by ten per cent.

3.2.2 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)

$C_V = 1.1$ 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

$C_f = 1.00$ 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 impact on flat bottom on forward area) and for test pressures and flooding loads

$C_i = 0.6$ for impact pressure on side shell and on platform bottom of multi hull

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:

$C_R = 1.0$ 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.
3.2.3 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 or under global hull girder loads

1) Minimum stress criterion in layers:

$$SF = C_V C_T C_R C_i$$

with:

$C_V$ : Partial safety factor:

- $C_V$ to be taken as defined in [3.2.2] item a) for the check of the structure under local loads
- $C_V = 1.1$ for the check of the global hull girder structure when examined as required in Ch 4, Sec 2, [1.1.3]

$C_T$ : Partial safety factor defined in [3.2.2]

$C_R$ : Partial safety factor defined in [3.2.2]

2) Combined stress criterion in layers:

$$SF_{CS} = C_{CS} C_V C_T C_i$$

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

$C_V$ : Partial safety factor defined in [3.2.2]

3) Critical buckling stress criterion:

$$SF_{B} = C_{Buck} C_V C_T C_i$$

with:

$C_{Buck}$, $C_V$ : Partial safety factors, to be taken equal to:

- $C_{Buck} = 1.45$ and $C_V$ as defined in [3.2.2] item a) for the check of the structure under local loads
- $C_{Buck} = 1.35$ and $C_V = 1.0$ for the check of the global hull girder structure when examined as required in Ch 4, Sec 2, [1.1.3]

b) For structure checked under local loads combined with global loads

When the structure check is carried out through a three-dimensional structural beam or a finite element model loaded simultaneously by global loads (as defined in Ch 3, Sec 2, [4] and Ch 3, Sec 2, [5]) and by local loads induced by external sea pressure and internal loads (as defined in Ch 3, Sec 3 and Ch 3, Sec 4), the rule safety factors are to be taken as follows:

1) Combined stress criterion in layers:

- for unidirectional tape, bi-bias, three-unidirectional fabric:
  $$SF_{CS} = 1.4 C_V C_T C_i$$
- for the other types of layer:
  $$SF_{CS} = 1.8 C_V C_T C_i$$

with:

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

2) Critical buckling stress criterion:

$$SF_{B} = 1.45 C_V C_T C_i$$

where:

$C_V$, $C_T$, $C_i$ : Partial safety factors defined in [3.2.2].

As a rule, the dynamic loads defined in Ch 3, Sec 3, [3], the testing loads defined in Ch 3, Sec 4, [5] and the flooding loads defined in Ch 3, Sec 4, [6] need not be taken into account when local and global loads are combined.

3.2.4 Rule safety factor for structural adhesive joints

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

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:

$$SF = 2.4 C_T$$

where:

$C_T$ : Factor taking into account the gluing process and generally taken as follows:

- $C_T = 1.4$ in case of a vacuum process with rising curing temperature
- $C_T = 1.5$ in case of vacuum process
- $C_T = 1.7$ in the other cases.

4 Plywood structure

4.1 General

4.1.1 Principle of design review

As a rule, plywood structures are checked according to an homogeneous material approach, or by a “ply by ply” approach as defined in NR546 Composite Ships.

4.2 Rule safety factors

4.2.1 Homogeneous material approach

As a general rule, the rule safety factor $SF$ to be taken into account in the global formula used to determine the plating thickness or the permissible stress in stiffeners is to be equal to, or greater than, 4.0.
4.2.2 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

\[ \text{SF} = C_R \cdot C_i \cdot C_V \]

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 parallel to the grain of the ply considered

- \( C_i \): Factor taking into account the type of loads.
  - \( C_i = 1.0 \) 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 applicable to the critical buckling stress criterion is to be calculated as follows:

\[ \text{SFB} = C_{\text{Buck}} \cdot C_V \cdot C_i \]

with:

- \( C_{\text{Buck}}, C_V \): Partial safety factors, to be taken equal to:
  - \( C_{\text{Buck}} = 1.45 \) and \( C_V = 1.2 \) for the check of the structure under local loads
  - \( C_{\text{Buck}} = 1.35 \) and \( C_V = 1.0 \) for the check of the global hull girder structure when examined as required in Ch 4, Sec 2, [1.1.3].

- \( C_i \): Partial safety factor defined in [3.2.2].

Note 1: For planing hull, when the global stress is calculated with the minimum bending moments defined in Ch 3, Sec 2, [6.1], \( C_i \) may be taken equal to 0.8.
# Chapter 3

## DESIGN LOADS

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SECTION 1  GENERAL

1 Application

1.1 General

1.1.1 As a general rule, the wave loads and the ship motions and accelerations defined in the present Chapter are assumed to be periodic and can be reached with a probability level of $10^{-5}$.

1.1.2 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 [1.1.1]. 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.

1.1.3 Requirements applicable to specific ship types

Additional specific loads, as defined in NR467 Steel Ships, Part D or Part E, may be considered in addition to those defined in the present Chapter, in relation to the service notation and the additional service features assigned to the ship (see Ch 6, Sec 1).

2 Definition

2.1 Hull girder loads

2.1.1 Hull girder loads (still water loads, wave loads and dynamic loads) are forces and moments which result from the effects of local loads acting on the ship as a whole and considered as a beam.

These loads are considered for the hull girder strength check and are defined in Sec 2.

2.2 Local external pressures

2.2.1 The local external pressures are local pressures (still water, wave and dynamic) applied to the individual local structure (plating, secondary stiffeners and primary supporting members).

These local external pressures are considered for the local structure check and are defined in Sec 3.

2.3 Local internal pressures and forces

2.3.1 The local internal pressures and forces are local pressures (still water and inertial pressure) applied to the local internal structure (plating, secondary stiffeners and primary supporting structure) and include liquid loads, dry cargoes (bulk, uniform or unit), wheeled loads and accommodation deck loads.

Flooding pressures induced by damage and testing pressures are also considered as local internal pressures.

These local internal pressures and forces are considered for the local internal structure check and are defined in Sec 4.

3 Local pressure application

3.1 Application

3.1.1 The local pressures to be used in the scantling checks of plating, secondary stiffeners and primary supporting members are the following ones:

a) For an element of the outer shell: the local external pressures (still water and wave) considered as acting alone, without any counteraction from the ship internal loads in ship full load condition.

However, for an element of the outer shell adjacent to a liquid compartment, the local load to be used in the scantling checks of plating, secondary stiffeners and primary supporting members of the shell is to be taken equal to the greater value between:

- the local load as defined just above, and
- for cargo ship:
  \[ p = p_{int} - 10 \left( T_B - h_1 - z \right) \]
  with:
  \[ T_B - h_1 - z \geq 0 \]
- for non cargo ship:
  \[ p = p_{int} - 10 \left( T - h_1 - z \right) \]
  with:
  \[ T - h_1 - z \geq 0 \]

where:

- $p_{int}$ : Local internal pressure, in kN/m², as defined in Sec 4
- $T$ : Draught, in m.
- $T_B$ : Draught in ballast condition, in m, measured from the base line

When $T_B$ is unknown, $T_B$ may be taken equal to 0.03 $L_{wl}$
h₁ : Ship relative motion in the considered area, in m, as defined in Sec 3, [2.1]

z : Load point calculation as defined in [4].

b) For an element inside the hull: the local internal pressures, the adjacent compartments being considered individually loaded, without any counteraction

c) For testing conditions: the internal testing pressures considered as acting alone, without external load counteraction

d) For flooding conditions: the internal flooding pressures on internal watertight elements considered without any counteraction on the internal watertight element considered.

3.1.2 Ship draught
The ship draught to be considered for the combination of the local loads is to correspond to:

- the full load condition: when one or more cargo compartments (oil tank, dry cargo hold, vehicle spaces) are considered as being loaded and the ballast tanks empty
- the light ballast condition: when one or more ballast tanks are considered as loaded and the cargo compartments empty (in the absence of more precise information, the ship’s draught in light ballast condition, in m, may be taken equal to 0,03 LWL).

4 Local load point location

4.1 General case for structures made of steel or aluminium alloys

4.1.1 Still water and wave loads
Unless otherwise specified, the local loads are to be calculated:

- for plate panels: at the lower edge of the plate panels
- for horizontal stiffeners: at mid-span of the stiffeners
- for vertical stiffeners: at the lower and upper vertical points of the stiffeners.

4.1.2 Dynamic loads
Unless otherwise specified, the dynamic loads are to be calculated:

- for plate panels: at mid-edge of the plate panels
- for longitudinal and transverse stiffeners: at mid-span of the stiffeners.

4.2 General case for structures made of composite materials

4.2.1 Still water and wave loads
Unless otherwise specified, the local loads are to be calculated:

- for plate panels:
  - at the lower edge of the plate panels for monolithic, and
  - at the middle of the plate panels for sandwich
- for horizontal stiffeners: at mid-span of the stiffeners
- for vertical stiffeners: at the lower and upper vertical points of the stiffeners.

4.2.2 Dynamic loads
Unless otherwise specified, the dynamic loads are to be calculated:

- for plate panels: at mid-edge of the plate panels
- for longitudinal and transverse stiffeners: at mid-span of the stiffeners.

4.3 Superstructures and deckhouses

4.3.1 For superstructures and deckhouses, the lateral pressures are to be calculated, for all type of materials:

- for plating: at mid-height of the bulkhead
- for horizontal and vertical stiffeners: at mid-span of the stiffeners.
SECTION 2  

HULL GIRDER LOADS

Symbols

- \( L_{WL} \) : Length at waterline at full load, in m
- \( L_{HULL} \) : Length of the hull from the extreme forward part to the extreme aft part of the hull, in m
- \( B_{WL} \) : Waterline breadth, in m, as defined in Ch 1, Sec 1, [4.3.2]
- \( B_{ST} \) : Waterline breadth of struts of swath, in m, as defined in Ch 1, Sec 1, [4.3.2]
- \( B_{sf} \) : Moulded breadth of the submerged float of swath, in m, as defined in Ch 1, Sec 1, [4.3.4]
- \( C_B \) : Total block coefficient as defined in Ch 1, Sec 1, [4.6]

As a rule, the value of \( C_B \) is to be taken at least equal to 0.4 in the present Section

- \( \Delta \) : Full load displacement, in t, at scantling draught in sea water \( (\rho = 1,025 \text{ t/m}^3) \)
- \( \Delta_{light} \) : Lightship weight, in t. For the purpose of the present Section, the lightship weight includes lubricating oil, fresh and feed water
- \( \Delta_b \) : Total displacement of the ship in ballast condition, in t
- \( T \) : Draught, at full load displacement, in m, measured at the midship transverse section. In the case of ship with a solid bar keel or equivalent, the draught is to be measured from the moulded base line (horizontal line tangent to the upper face of bottom plating) to the full load waterline
- \( D_W \) : Maximum deadweight of the ship, in t, equal to the difference between the full load displacement and the light ship weight
- \( n \) : Navigation coefficient depending on the assigned navigation notation, defined in Ch 1, Sec 1, [3]
- \( g \) : Gravity acceleration taken equal to 9.81 m/s².

1  General

1.1  Hull girder loads

1.1.1 The hull girder loads considered in the present Rules are the:
- still water loads: induced by the longitudinal distribution of the lightship, the internal loads (cargo and ballast) and the buoyancy in still water condition
- wave loads: induced by the encountered waves in head sea condition and, in addition for multihull, in quartering sea condition
- impact loads: induced by the bottom impact in waves (for planing hull only)
- digging in wave loads: induced by the encountered waves when the fore part of each float is burying into the waves (for multihull only)
- waves acting on the twin hull (for swath only).

1.1.2 These different hull girder loads are to be combined as defined in [3] in order to check:
- the longitudinal hull girder scantlings, and
- in addition for multihull, the transverse structure of platform and the longitudinal float girder scantlings.

2  Calculation convention

2.1  Sign conventions of global bending moments and shear forces

2.1.1 The sign conventions of bending moments and shear forces, at any ship transverse section, induced by the hull girder loads are as shown in Fig 1, namely:
- the bending moment \( M \) is positive when it induces tensile stresses in the strength deck (hogging bending moment); it is negative in the opposite case (sagging bending moment, inducing compression stresses in the strength deck)
- the vertical shear force \( Q \) is positive in the case of downward resulting forces preceding, and upward resulting forces following, the ship transverse section under consideration; it is negative in the opposite case.

Figure 1 : Sign conventions of bending moments and shear forces

\[ Q: \quad (+) \quad \text{Aft} \quad \text{Fore} \]
\[ M: \quad (+) \]
2.2 Designation of global bending moments and shear forces

2.2.1 Global bending moments
The designation of the bending moments is as follows:

- Bending moments in still water condition:
  - M_{SWH} for hogging conditions
  - M_{SWS} for sagging conditions
- Wave bending moments induced by head sea condition:
  - M_{WH} for hogging conditions
  - M_{WS} for sagging conditions
- Wave bending moments induced by quartering sea condition (for multihull only):
  - M_{WQH} for hogging conditions
  - M_{WQS} for sagging conditions
- Minimum combined bending moments induced by bottom impact in wave and still water conditions (for planning hull only):
  - Vertical moments:
    - M_{minH} for hogging conditions
    - M_{minS} for sagging conditions
  - Transverse torsional moment (for multihull only): M_{ttmin}
- Bending moment induced by digging in wave (for multihull only):
  - M_{DWL} for bending moment applied to the floats of multihull
  - M_{DWT} for bending moment applied to the primary transverse structure of the platform of multihull
- Transverse bending moment acting on twin-hull connection (for swath only):
  - M_Q

2.2.2 Vertical shear forces
The vertical shear forces Q are designed with the same suffixes as those defined for the bending moments in [2.2.1].

3 Combination of hull girder loads

3.1 Hull girder load combinations

3.1.1 Ship in displacement mode
The bending moments and the combinations to be considered for the hull girder analysis are defined in Tab 1.

The shear forces and the combinations to be considered for the hull girder analysis are based on the same principle than the combinations of the bending moments defined in Tab 1.

3.1.2 Sailing ship
When the ship is fitted with masts for sailing navigation, the bending moments M_{BC} and the shear forces Q_{BC} induced by the standing rigging and to be taken into account for the hull girder analysis are defined in NR500 Rules for the Classification and the Certification of Yachts.

These moments and shear forces are to be combined with the loads combinations defined in [3.1.1] as defined in NR500 Classification of Yachts.

### Table 1: Hull girder load combinations for ship in displacement mode

<table>
<thead>
<tr>
<th>Ship condition</th>
<th>Monohull ship</th>
<th>Multihull ship</th>
</tr>
</thead>
<tbody>
<tr>
<td>All type of ship</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head sea condition (hogging)</td>
<td>M_{SWH} + M_{WH}</td>
<td></td>
</tr>
<tr>
<td>(sagging)</td>
<td>M_{SWS} + M_{WS}</td>
<td></td>
</tr>
<tr>
<td>Quartering sea condition (hogging)</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>(sagging)</td>
<td>NA</td>
<td>M_{minH} + M_{WQH}</td>
</tr>
<tr>
<td>Digging in wave (sagging)</td>
<td>NA</td>
<td>M_{SWS} + M_{WQS}</td>
</tr>
</tbody>
</table>

In addition, for ship in planning mode

| Head sea condition (hogging or sagging) | M_{minH} or M_{minS} (1) |
| Quartering sea condition | NA | M_{ttmin} |

Note 1: NA = Not applicable.
(1) Not applicable to swath.

3.2 Hull girder loads distribution

3.2.1 The hull girder loads defined in [3.1] are to be applied along the ship from 0,3 L from the aft end to 0,7 L from the aft end.

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

4 Still water loads

4.1 Cargo ships

4.1.1 General
As a rule, for cargo ships as defined in Ch 1, Sec 1, [2.1.2], the longitudinal distribution of still water bending moments and shear forces for homogeneous loading conditions at full load displacement and for ballast condition, subdivided into departure and arrival conditions, is to be submitted to the Society.

The data necessary to calculate the still water bending moments and shear forces are to be submitted to the Society for information.

When these informations are not available, the still water bending moments and shear forces in full load and ballast conditions may be taken as defined in [4.1.4].

b) Still water load specification
The longitudinal distribution of still water bending moments and shear forces is a basis for the hull girder strength review. The values of these still water bending moments and shear forces considered for the structure review (rule or designer values) are to be indicated on the midship section drawing.
4.1.2 For ships having alternate light and heavy cargo loading conditions, see Ch 1, Sec 1, [1.2.2].

4.1.3 Particular types of ship
Supply vessels, barges, fishing vessels, and all types of ship not considered as cargo ships as defined in Ch 1, Sec 1, [2.1.2] but liable to carry loading or equivalent loads, may be however examined, for a hull girder load in still water point of view, with the present requirements for cargo ships, when deemed necessary by the Society.

4.1.4 Still water bending moments and shear forces

a) Hogging conditions
In hogging conditions, the maximum bending moment \( M_{SWH} \), in kN-m, and the maximum shear force \( Q_{SWH} \), in kN, may be calculated, in ballast condition, as follows:
\[
M_{SWH} = 5 \left[ 0.28 \left( \frac{LWL}{\Delta} \right) + \sum (x_i DW_{loci}) - 0.198 \left( \frac{LWL}{\Delta} \right) \right] - 0.198 \left( \frac{LWL}{\Delta} \right)
\]
\[
Q_{SWH} = \frac{4M_{SWH}}{LWL}
\]
where:
- \( DW_{loci} \): Weight, in t, of the ballasts considered
- \( x_i \): Distance, in m, between the midship perpendicular and the centre of gravity of the considered ballasts (the sign of \( x_i \) is always to be considered positive)

Note 1: When the value of \( M_{SWH} \) is negative, \( M_{SWH} \) is to be considered as a minimum sagging moment (in this case, the ship is always in sagging condition in still water).

b) Sagging conditions
In sagging conditions, the maximum bending moment \( M_{SWS} \), in kN-m, and the maximum shear force \( Q_{SWS} \), in kN, may be calculated, in full load condition (for homogeneous loading case only), as follows:
\[
M_{SWS} = 5 \left[ 0.28 \left( \frac{LWL}{\Delta} \right) + X DW - 0.225 \left( \frac{LWL}{\Delta} \right) \right]
\]
\[
Q_{SWS} = \frac{4M_{SWS}}{LWL}
\]
where:
- \( X \): Distance, in m, taken equal to:
  \[
  X = \frac{(0,5\Delta_{SW} - X_1)^2 + (X_2 - 0,5\Delta_{SW})^2}{2(X_2 - X_1)}
  \]
- \( X_1, X_2 \): Distances, in m, between the aft perpendicular of the ship and, respectively, the aft boundary and the fore boundary of the cargo holds.

Note 2: When the value of \( M_{SWS} \) is positive, \( M_{SWS} \) is to be considered as a minimum hogging moment (in this case, the ship is always in hogging condition in still water).

Note 3: These formulae are to be used only for ships having their machinery space and superstructure located in the ship aft part.

c) Hogging and sagging conditions for catamaran and swath considered as cargo ships
For catamaran and swath considered as cargo, the maximum values of bending moments and shear forces in hogging and sagging conditions calculated according to item a) and item b) are to be reduced by 50%.

4.2 Non cargo ships

4.2.1 Still water bending moments and shear forces
a) Hogging conditions for monohull and catamaran
In hogging conditions, the maximum bending moment \( M_{SWH} \), in kN-m, and the maximum shear force \( Q_{SWH} \), in kN, may be calculated as follows:
\[
M_{SWH} = 0.8 \left( \frac{C_W \cdot L^2 \cdot B_{WL}}{C_W} \right)
\]
\[
Q_{SWH} = \frac{4M_{SWH}}{LWL}
\]
where:
- \( L_W, C_W \): Wave length and wave parameter, respectively, as defined in [5.2.2]

b) Sagging conditions for monohull and catamaran
In sagging conditions, the maximum bending moment \( M_{SWS} \), in kN-m, and the maximum shear force \( Q_{SWS} \), in kN, may be taken equal to:
\[
M_{SWS} = Q_{SWS} = 0
\]

c) Hogging and sagging conditions for swath
In hogging and sagging conditions, the maximum bending moments and the maximum shear forces for swath are to be calculated as defined in item a) and item b), using the breadth \( B_{sw} \) instead of \( B_{WL} \) in the formulae.

For ships having a superstructure distribution all along the ship length or located in the midship area from 0.3 L to 0.7 L from the aft end, the maximum bending moments and the maximum shear forces in hogging conditions may be reduced by 40%.

5 Wave loads

5.1 General

5.1.1 Ship in displacement mode
Wave loads are induced by the encountered waves in head sea condition.
The design encountered waves, considered with a probability level of 10\(^{-5}\), are represented by an equivalent static wave defined in [5.2.2].

As an alternative, the Society may accept the values of wave induced loads derived from direct calculations, when justified on the basis of the ship characteristics and intended service. The calculations are to be submitted to the Society for approval.

5.1.2 Ship in planing mode
In addition to the calculation to be carried out as defined in [5.1.1], the combined bending moments and shear forces induced by impact loads are to be calculated according to [6.1] for planing hull.

As an alternative, the Society may accept the values of impact loads derived from direct calculations, when justified on the basis of the ship characteristics and intended service. The calculations are to be submitted to the Society for approval.
5.1.3 Additional wave loads for multihull

Wave loads are induced by the encountered waves in quartering sea condition. The design encountered waves, considered with a probability level of $10^{-9}$, are represented by an equivalent static wave defined in [5.3.1].

As an alternative, the Society may accept the values of wave induced loads and impact loads derived from direct calculations, when justified on the basis of the ship characteristics and intended service. The calculations are to be submitted to the Society for approval.

In addition to the moment defined in head sea condition, the torsional moments applied to the platform of multihull (inducing bending moment and shear force in the floats and in the primary transverse cross structure of the platform) are to be calculated according to the following hypotheses:

- For multihull:
  - 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 (see [5.3])
  - digging in wave: the fore part of each float buries into the wave down to a depth as defined in [6.2.1]

- In addition, for swath:
  - wave acting on twin hull (see [6.2.2]).

5.2 Wave loads in head sea condition

5.2.1 Wave loads in head sea condition

The bending moments and shear forces induced by wave in head sea condition are calculated according to [5.2.3], considering the following hypotheses:

- the forward and aftward perpendiculars of the hull are on the crest (sagging conditions), or
- the forward and aftward perpendiculars of the hull are on the trough (hogging conditions).

The values obtained are to be applied along the ship from 0.3 L to 0.7 L from the aft end.

When deemed necessary by the Society, a distribution of the bending moments and shear forces as defined in NR467 Steel Ships, Ch 5, Sec 2, [3] may be considered.

5.2.2 Wave characteristics for head sea condition

The characteristics of the encountered waves to be considered in head sea condition (equivalent static wave) are as follows:

- sinusoidal type
- wave length $L_{W}^{}$, in m, equal to:
  
  $L_{W}^{} = 0.5 \left( L_{W1}^{} + L_{W2}^{} \right)$

- wave parameter $C_{W}$, in m, equal to:
  
  $C_{W} = 0.625 \left( 118 - 0.36 L_{W}^{} \right) L_{W}^{} \cdot 10^{-3}$

5.2.3 Wave bending moments and shear forces

a) Hogging conditions for monohull ship

In hogging conditions, the maximum bending moment $M_{WH}$, in kN-m, and the maximum shear force $Q_{WH}$, in kN, along one float in head sea condition, are obtained from the following formulae:

\[
M_{WH} = 0.20 n C_{W} L_{W}^2 B_{WL} C_{B}
\]

\[
Q_{WH} = 0.65 n C_{W} L_{W} B_{WL} C_{B}
\]

b) Sagging conditions for monohull ship

In sagging conditions, the maximum bending moment $M_{WS}$, in kN-m, and the maximum shear force $Q_{WS}$, in kN, along one float in head sea condition, are obtained from the following formulae:

\[
M_{WS} = -0.25 n C_{W} L_{W}^2 B_{WL} C_{B}
\]

\[
Q_{WS} = -0.75 n C_{W} L_{W} B_{WL} C_{B}
\]

where:

$L_{W}$, $C_{W}$ : Wave length and wave parameter, respectively, as defined in [5.2.2]

$B_{WL}$ : Breadth at waterline, in m, of one float.

c) Hogging and sagging conditions for catamaran

The maximum values of the wave bending moments and shear forces for catamaran are to be calculated as defined in items a) and b), increased by 10%.

d) Hogging and sagging conditions for swath

The maximum values of the wave bending moments and shear forces for swath are to be calculated as defined in item c), using the breadth $B_{S}$ instead of $B_{WL}$ in the formulae.

5.3 Wave loads in quartering sea condition for multihull

5.3.1 Wave characteristics for quartering sea condition

The characteristics of the encountered waves to be considered in quartering sea condition (equivalent static wave) are as follows:

- sinusoidal type
- wave length $L_{WQ}$, in m, resulting from the quartering wave position and defined as follows (see Fig 2):

\[
L_{WQ} = \frac{2 L_{W} B_{f}}{\sqrt{L_{W}^2 + B_{f}^2}}
\]

where:

$L_{W}$ : Wave length, in m, as defined in [5.2.2]

$B_{f}$ : Distance, in m, between the float axes (see Fig 2)

- wave parameter $C_{WQ}$, in m, equal to:

\[
C_{WQ} = 0.625 \left( 118 - 0.36 L_{WQ} \right) L_{WQ} \cdot 10^{-3}
\]
5.3.2 Wave bending moments and shear forces for multihull

a) Hogging and sagging conditions for catamaran

The bending moments $M_{\text{WQH}}$ and $M_{\text{WQS}}$, in kN·m, and the shear forces $Q_{\text{WQH}}$ and $Q_{\text{WQS}}$, in kN, are to be calculated as follows:

- in hogging conditions:
  $$M_{\text{WQH}} = n \frac{C_{\text{WQ}} L_{\text{W}}^2}{2} B_{\text{WL}} C_{\text{B}}$$
  $$Q_{\text{WQH}} = 1.60 n \frac{C_{\text{WQ}} L_{\text{W}}}{B_{\text{WL}} C_{\text{B}}}$$

- in sagging conditions:
  $$M_{\text{WQS}} = - n \frac{C_{\text{WQ}} L_{\text{W}}^2}{2} B_{\text{WL}} C_{\text{B}}$$
  $$Q_{\text{WQS}} = - 1.60 n \frac{C_{\text{WQ}} L_{\text{W}}}{B_{\text{WL}} C_{\text{B}}}$$

where:

$C_{\text{WQ}}$ : Wave parameter as defined in [5.3.1]
$L_{\text{W}}$ : Wave length, in m, as defined in [5.2.2].

b) Hogging and sagging conditions along the floats and in the platform for catamaran

The bending moments and the shear forces along the floats as well as those in the primary transverse cross structure of the platform are to be determined by a beam model as defined in Ch 4, Sec 2, [4.3].

The beam model is to be loaded by forces $F$, in kN, as shown on Fig 3, where $F$ is successively equal to:

$$F = \frac{M_{\text{WQH}}}{L_{\text{WL}}}$$
$$F = \frac{M_{\text{WQS}}}{L_{\text{WL}}}$$

where:

$M_{\text{WQH}}$, $M_{\text{WQS}}$ : Bending moments, in kN·m, as defined in item a).
$L_{\text{WL}}$ : Length at waterline at full load, in m

C) Hogging and sagging conditions along the floats and in the platform for swath

The bending moments and the shear forces along the floats and in the platform are to be calculated as defined in item b), using the breadth $B_{\text{ST}}$ instead of $B_{\text{WL}}$ in the formulae of bending moments $M_{\text{WQH}}$ and $M_{\text{WQS}}$. 
6 Additional specific wave hull girder loads

6.1 Additional wave loads for planing hull

6.1.1 Minimum bending moments and shear forces in head sea condition

a) Hogging and sagging conditions for monohull

For monohull planing hull as defined in Ch 1, Sec 1, [2.1.4], the minimum combined bending moments $M_{\text{minH}}$ and $M_{\text{minS}}$, in kN·m, and the minimum shear forces $Q_{\text{minH}}$ and $Q_{\text{minS}}$, in kN, in planing hull mode (due to still water plus wave induced loads plus impact loads) are to be not less than the following values:

- in hogging conditions:
  $M_{\text{minH}} = 0.55 \Delta L_{WL} (C_B + 0.7) (1 + a_{CG})$
  $Q_{\text{minH}} = \frac{3.2 M_{\text{minH}}}{L_{WL}}$

- in sagging conditions:
  $M_{\text{minS}} = -0.55 \Delta L_{WL} (C_B + 0.7) (1 + a_{CG})$
  $Q_{\text{minS}} = \frac{3.2 M_{\text{minS}}}{L_{WL}}$

where:

- $a_{CG}$ : Vertical design acceleration at $L_{CG}$, expressed in g, as defined in Sec 3, [3.3.4]

The minimum water bending moments and shear forces are to be applied along the ship from 0.3 $L$ to 0.7 $L$ from the aft end.

b) Hogging and sagging conditions for catamaran

For catamaran planing hull as defined in Ch 1, Sec 1, [2.1.4], the minimum combined bending moments $M_{\text{minH}}$ and $M_{\text{minS}}$, in kN·m, and the minimum shear forces $Q_{\text{minH}}$ and $Q_{\text{minS}}$, in kN, in planing hull mode (due to still water plus wave induced loads plus impact loads) applied to one float are to be taken equal to the values defined in [6.1.1] reduced by 50%.

As an alternative to items a) and b), the Society may accept the values of hull girder bending moments induced by still water plus wave loads plus impact loads in the fore body area derived from direct calculation or obtained by model test.

6.1.2 Minimum bending moments and shear forces in quartering sea condition (catamaran only)

a) Bending moment

For catamaran designed with planing hull as defined in Ch 1, Sec 1, [2.1.4], the minimum transverse torsional moment $M_{\text{ttmin}}$, in kN·m, due to wave induced loads plus impact loads is not to be less than:

$M_{\text{ttmin}} = 0.125 \Delta L_{WL} a_{CG} g$

where:

- $a_{CG}$ : Design vertical acceleration as defined in Sec 3, [3.3.4]. In the above formula, $a_{CG}$ need not be taken greater than 1.0 g.

b) Bending moments and shear forces along the floats and in the platform

The bending moments and the shear forces along the floats as well as those in the primary transverse cross structure of the platform are to be determined by a beam model as defined in Ch 4, Sec 2, [4.3].

The beam model is to be loaded by forces $F$, in kN, as shown on Fig 3, where $F$ is successively equal to:

$F = \frac{M_{\text{min}}}{L_{WL}}$

$F = -\frac{M_{\text{ttmin}}}{L_{WL}}$
6.2 Additional wave loads for multihull

6.2.1 Digging in wave loads

a) Application

The digging in wave loads correspond to the situation where the multihull sails in quartering sea condition and has the fore end of the floats burying into the encountered waves.

b) Bending moment and shear force for catamaran

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

The bending moment $M_{DWL}$, in kN⋅m, and the shear force $Q_{DWL}$, in kN, in the floats and in the platform of the catamaran are to be calculated by a beam model as defined in Ch 4, Sec 2, [4.3], taking into account the following fore float loads (see Fig 4):

- for the float the more sunk in the wave:

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

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

- for the float the less sunk in the wave:

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

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

where:

$L_W$ : Wave length, in m, as defined in [5.2.2].

$F'$ : Vertical Archimedian overpressure force, in kN, equal to:

$F' = \frac{1}{8}\rho g \Delta A \frac{\delta_1 + \delta_2}{d} \cdot n$

$F''$ : Horizontal Archimedian overpressure force, in kN, equal to:

$F'' = F' \cos 80^\circ$

$d$ : 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

$A_p$ : Pitch amplitude, in rad, as defined in Sec 4, [2.1.5]

$\delta_1, \delta_2$ : Vertical heights of the digging in wave, in m, of a point located at $d/2$ abait fore end of each float, calculated as follows:

$\delta_1 = \frac{1}{3} L_W A_p$

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

The vertical and horizontal linear loads $F_v$ and $F_h$ are to be applied from the fore part of the floats on a distribution length, in m, equal to $L_{FM} / 4$ without being taken greater than $d$, as shown on Fig 4.

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

Figure 4 : Multihull loads due to digging in wave
c) Bending moments and shear forces for swath
The bending moment $M_{\text{DWL}}$, in kN\(\cdot\)m, and the shear force $Q_{\text{DWL}}$, in kN, in the floats and in the platform of the swath are to be calculated as defined in item b), taking into account a vertical Archimedian overpressure $F'$, in kN, equal to:

$$F' = \frac{1,5 g \Delta (0,2125) A_{\lambda}}{\delta_1 + \delta_2} \cdot n$$

6.2.2 Bending moment acting on twin-hull connections of swath
The bending moment $M_Q$, in kN\(\cdot\)m, applied along the platform structure of swath is to be taken equal to:

$$M_Q = h_M F_q$$

where:

$h_M$ : Half the draught $T$, in m, plus the distance from the waterline at draught $T$ to the midpoint of the platform structure (see Fig 5)

$F_q$ : Side beam force, in kN, equal to:

$$F_q = 12,5 n T \Delta^{2/3} d_1 L_S$$

with:

$$d_1 = 1,55 - 0,75 \ \tanh(\Delta/11000)$$

$$L_S = 2,99 \ \tanh(\lambda - 0,275)$$

$$\lambda = 0,137 A_{\text{lat}} / (T \Delta^{1/3})$$

$A_{\text{lat}}$ : Lateral surface, in m$^2$, projected on a vertical plane of one hull with that part of strut or struts below the waterline at draught $T$.

Figure 5 : Side beam force
SECTION 3  LOCAL EXTERNAL PRESSURES

Symbols

$L_{WL}$ : Length at waterline at full load, in m
$L_{HULL}$ : Length of the hull from the extreme forward part to the extreme aft part of the hull, in m

Base Line: As a rule, the base line is a fictive line located at the lower point of the hull bottom where $z = 0$ (see Fig 1)

$L_H = 0,5 \left( L_{WL} + L_{HULL} \right)$

$C_W = 0,625 \left( 118 - 0,36 L_W \right) L_W 10^{-3}$

$C_B$ : Total block coefficient as defined in Ch 1, Sec 1, [4.6]

$D$ : Depth, in m, as defined in Ch 1, Sec 1, [4]

$\Delta$ : Full load displacement, in t, at scantling draught in sea water ($\rho = 1,025$ t/m$^3$)

$T$ : Draught, at full load displacement, in m, measured from the base line (see Fig 1)

$T_B$ : Draught, at ballast displacement, in m, measured from the base line

If $T_B$ is unknown, $T_B$ may be taken equal to 0,03 $L_{WL}$

$n$ : Navigation coefficient depending on the assigned navigation notation, defined in Ch 1, Sec 1, [3]

$z$ : Z co-ordinate, in m, at the calculation point as defined in Sec 1, [4]

$\rho$ : Sea water density, taken equal to 1,025 t/m$^3$

$g$ : Gravity acceleration taken equal to 9,81 m/s$^2$

$V$ : Maximum ahead service speed, in knots.

1 Definitions

1.1 General

1.1.1 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: to be calculated for the plating and the secondary stiffeners only (see [3.1])
- bottom impact pressure on flat bottom forward area: to be calculated for the structural elements of forward bottom, where applicable (see [3.3])
- bottom slamming pressure: to be calculated for the structural elements of the bottom of planing hull as defined in Ch 1, Sec 1, [2.1.4] (see [3.3]) where slamming may occur.

Note 1: Side shell primary stiffeners and cross deck primary stiffeners are, as a general rule, examined with sea pressures only, without taking into account the side shell and cross deck impacts.

1.1.2 Local internal pressure

Local internal pressures are loads induced by liquid cargoes, dry cargoes, accommodations, testing loads and flooding loads.

1.1.3 Wheel loads on deck, when applicable.
# 2 Sea pressures

## 2.1 Ship relative motions

### 2.1.1 General

Ship motions are defined, with their sign, according to the reference co-ordinate system in Ch 1, Sec 1, [5] and are assumed to be periodic.

The ship relative motions $h_1$ are the vertical oscillating translations of the sea surface on the ship side. It is measured, with its sign, from the waterline at draught $T$ and may be assumed as:

- symmetrical on the ship sides (upright ship conditions)
- with an amplitude equal to the half of the crest to trough of the encountered wave.

The ship relative motions $h_1$, in m, are to be calculated for cargo and non cargo ships as defined in Tab 1.

## 2.2 Sea pressures

### 2.2.1 Bottom and side shell

The sea pressure on bottom and side shell in the different longitudinal parts of the hull are obtained, in kN/m$^2$, as follows:

- for bottom structure:
  \[
  P_b = \rho g (T + h_1 + h_2 - z_0)
  \]

  Note 1: In case of important deadrise angle, the bottom sea pressure may be calculated as defined for the side shell structure.

- for side shell structure:
  
  the greater value obtained from the following formulae, without being taken greater than the sea pressure calculated for the bottom:

  \[
  P_s = \rho g (T + 0.8B_\ell \sin \phi_3 - z)
  \]

  \[
  P_s = P_{d\text{min}}
  \]

  where:

  - $z_0$ : Distance, in m, between the base line and the bottom hull in the considered section (see Fig 1).
  - $z_0$ may be taken negative if the calculation point is located below the base line.
  - $z$ : Distance, in m, between the base line and the calculation point in the considered section (see Fig 1).
  - $P_{d\text{min}}$ : Minimum sea pressure on exposed deck, in kN/m$^2$, as defined in [2.2.2], in the considered section, with $\phi_1$ and $\phi_3$ taken equal to $1.00$.
  - $h_1$ : Ship relative motion, in m, in the different longitudinal parts of the hull as defined in Tab 1.
  - $\phi_1$ and $\phi_3$ taken equal to $1.00$.
  - $h_2$ : Parameter, in m, equal to:

    - for monohull:
      
      \[
      h_2 = 0
      \]

    - for catamaran:
      - for bottom, internal side shell and platform bottom:
        \[
        h_2 = 0
        \]
      - for external side shell:
        \[
        h_2 = 0
        \]

    - for swath:
      
      \[
      h_2 = 0
      \]

### Table 1: Ship relative motion $h_1$

<table>
<thead>
<tr>
<th>Location</th>
<th>Relative motion $h_{1,m}$, in m, for cargo ship</th>
<th>Relative motion $h_{1,m}$, in m, for non cargo ship</th>
</tr>
</thead>
<tbody>
<tr>
<td>from aft part to 0,25 LWL</td>
<td>$h_{1,A} = 0,6\left(4,35 \frac{C_b}{\sqrt{T_b}} - (3,25)\right)h_{1,m} + h_{1,m}$</td>
<td>$h_{1,A} = 1,1h_{1,m}$</td>
</tr>
<tr>
<td>from 0,25 LWL to 0,70 LWL</td>
<td>$h_{1,m} = 0,36n C_{W}(C_b + 0,7)$ (1)</td>
<td>$h_{1,m} = (0,38C_{W} + 0,3)n$ (2)</td>
</tr>
<tr>
<td>from 0,70 LWL to 0,85 LWL</td>
<td>$h_{1,1} = h_{1,m} + 0,125h_{1,1} - h_{1,1}$</td>
<td>$h_{1,1} = 1,4h_{1,m} + 0,7h_{1,1}$</td>
</tr>
<tr>
<td>from 0,85 LWL to fore part</td>
<td>$h_{1,1} = 1,2h_{1,m} \left(4,35 \frac{C_b}{\sqrt{T_b}} - 3,25\right)C_{W}$</td>
<td>$h_{1,1} = 1,7h_{1,m} \left(\frac{7,6}{C_b} - 6,4\right)C_{W}$</td>
</tr>
</tbody>
</table>

Note 1:

- $C_{W}$ : Coefficient, to be taken as follows:
  - for monohull: $C_{W} = 1,00$
  - for catamaran: $C_{W} = 1,20$
  - for swath: $C_{W} = 0,75$

(1) The value of $h_{1,m}$ is not to be taken greater than the minimum of $T$ and $(D - 0.9 T_b)$.

(2) The value of $h_{1,m}$ is not to be taken greater than $T$. 

---

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B1 : Reference breath to be taken as follows:
- for monohull: B1 = BWLi
- for catamaran: B1 = Bc + BWLi
- for swath: B1 = Bc + BSTi

where:
BWLi, Bc, BSTi : Moulded breaths as defined in Ch 1, Sec 3, [1.2.1], measured at the middle of the area considered;

2.2.2 Exposed deck

The local external loads, in kN/m², on exposed decks are obtained from the following formula:

\[ P_d = (P_0 - 10 \cdot z_d) \cdot \varphi_1 \cdot \varphi_2 \cdot \varphi_3 \geq P_{\text{min}} \]

where:

- \( P_0 \) : Sea pressure, in kN/m², in the considered section calculated at the base line according to [2.2.1] (\( z_0 \) taken equal to 0)
- \( z_d \) : Vertical distance, in m, between the deck and the base line at the considered transverse section
- \( \varphi_1 \) : Coefficient for pressure on exposed deck, equal to:
  - for freeboard deck: \( \varphi_1 = 1,00 \)
  - for top of lowest tier: \( \varphi_1 = 0,75 \)
  - for top of second tier: \( \varphi_1 = 0,56 \)
  - for top of third tier: \( \varphi_1 = 0,42 \)
  - for top of fourth tier and above: \( \varphi_1 = 0,32 \)
- \( \varphi_2 \) : Coefficient taken equal to:
  \[ \varphi_2 = \frac{LWL}{120} \geq 0,42 \]
- \( \varphi_3 \) : 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.

**2.2.3 Exposed deck with cargo**

As a rule, the local external loads, in kN/m², on exposed deck supporting cargo are to be taken equal to the sum of:
- cargo load as defined in Sec 4, [3] on the part of the deck loaded by cargo, and
- external load as defined in [2.2.2] on the part of the deck not protected by the cargo and exposed to green sea effect.

**2.2.4 Other type of exposed deck**

The local external loads of exposed deck which are not accessible to the passengers and/or crew not directly exposed to sea pressure may be taken equal to 1,3 kN/m². The local external loads on superstructures decks are defined in Ch 5, Sec 1.

Local forces on deck induced by containers, lashing, wheel loads, etc, are to be calculated as defined in Sec 4.

### 3 Dynamic sea pressures

#### 3.1 Side shell impact and platform bottom impact

**3.1.1 General**

The side shell impact and the platform bottom impact (for multihull) are local loads and represents 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 scantling draught 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 plane of the side shell.

The side shell impact and platform bottom impact (for multihull) may be disregarded for ships having the service notation launch or sheltered water or having an operating area notation assigned to ships intended to operate only within 5 miles from shore.

**3.1.2 Impact calculation on side shell**

The impact pressure \( p_{\text{min}} \), in kN/m², acting on the side shell is not to be less than:

\[ p_{\text{min}} = C_i \cdot n_i \]

where:

- \( C_i \) : Dynamic load, in kN/m² defined in Tab 2.
- \( n_i \) : Coefficient depending on the assigned navigation notation or operating area notation, to be taken equal to:
  - 1 for unrestricted navigation
  - 0,9 for summer zone
  - 0,8 for tropical zone
  - 0,7 for coastal area or operating area notation assigned to ships intended to operate only within 20 miles from shore
  - 0,6 for sea going launch.
3.1.3 Impact calculation on internal side shell and platform bottom of multihull

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

$$p_{\text{ssmin}} = C_i n_1$$

where:

- $C_i$ : Dynamic load, in kN/m$^2$ defined in Tab 3.
- $n_1$ : Coefficient depending on the assigned navigation notation or operating area notation, to be taken equal to:
  - 1 for unrestricted navigation
  - 0.9 for summer zone
  - 0.8 for tropical zone
  - 0.7 for coastal area or operating area notation assigned to ships intended to operate only within 20 miles from shore
  - 0.6 for sea going launch.

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 2).

### Table 2: Dynamic load $C_i$ on side shell

<table>
<thead>
<tr>
<th>Area</th>
<th>from T to T+1, in m</th>
<th>from T+1 to T+3, in m</th>
<th>above T+3, in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>from aft part to 0.70 $L_{\text{WL}}$</td>
<td>55</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>from 0.70 $L_{\text{WL}}$ to fore part</td>
<td>70</td>
<td>55</td>
<td>30</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Area</th>
<th>Areas (see Fig 2)</th>
<th>from T to T+1, in m</th>
<th>from T+1 to T+3, in m</th>
<th>above T+3, in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area 5</td>
<td>55</td>
<td>40</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Area 6</td>
<td>70</td>
<td>55</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Area 7</td>
<td>80</td>
<td>70</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Bottom impact pressure for flat bottom forward area

3.2.1 Application

The present requirements are applicable for ships having:
- a navigation notation other than sheltered area
- a flat bottom shape on the forward hull body, and
- a minimum forward draught, in m, in ballast condition or in partial loading operation less than 0.04 $L$.

Note 1: For pontoon shaped ships, when a reduction of the speed is provided in relation with the sea state to avoid bottom impact pressure for flat bottom area, the present requirements are not applicable.

Note 2: For ships having the navigation notation coastal area, a reduction of 20% may be applied on the bottom impact pressure, on a case-by-case basis.

3.2.2 Area to be considered

The flat bottom area is considered as the area limited to:
- longitudinally: area in aft of the fore end, from 0.05 $L_{\text{WL}}$ to 0.25 $(1.6 - C_{B}) L_{\text{WL}}$, without being taken less than 0.2 $L_{\text{WL}}$ nor greater than 0.3 $L_{\text{WL}}$
- transversely and vertically: over the whole flat bottom and the adjacent zones up to a height from the base line not less, in mm, than 2 $L_{\text{WL}}$, limited to 300 mm.
3.2.3 Bottom impact pressure for flat bottom area

a) Plating and secondary stiffeners

The bottom impact pressure $p_{BI}$ in kN/m$^2$, for the plating and secondary stiffeners is to be obtained from the following formula:

$$p_{BI} = 62 C_1 T_{\text{min}}$$

where:

- general case:
  $$C_1 = \frac{119 - 2300 T_{\text{min}}}{78 + 1800 T_{\text{min}}}$$
  with $0 < C_1 \leq 1$

- non propelled units:
  $$C_1 = \frac{119 - 2300 T_{\text{min}}}{156 + 3600 T_{\text{min}}} + 0.09$$
  with $0 < C_1 \leq 0.59$

where:

- $T_{\text{min}}$: Minimum forward draught, in m.

b) Primary stiffeners

The bottom impact pressure in kN/m$^2$, for the primary stiffeners is to be taken equal to $0.3 p_{BI}$, where $p_{BI}$ is the bottom impact pressure for plating and secondary stiffeners calculated in item a).

3.3 Bottom slamming for planing hull

3.3.1 General

Slamming phenomenon on bottom area, induced by heave acceleration in planing hull mode, is to be considered on planing hull as defined in Ch 1, Sec 1, [2.1.4].

As a rule, bottom slamming loads are to be calculated on bottom area, up to the limit of bilges or hard chines, and from the transom to the fore end, for monohull and catamaran.

3.3.2 Bottom slamming pressures

The slamming pressure $p_{sl}$, in kN/m$^2$, considered as acting on the bottom of planing hull is to be not less than:

$$p_{sl} = P_{sl1} K_{2}$$

where:

- $K_2$: Area factor defined in [3.3.3], item b)
- $P_{sl1}$: Design bottom slamming pressure, in kN/m$^2$, equal to:

  $$P_{sl1} = 100 \ T \ K_1 \ K_3 \ a_{CG}$$

- $K_1$: Distribution factor defined in [3.3.3], item a)
- $K_3$: Bottom shape factor defined in [3.3.3], item c)
- $a_{CG}$: Vertical design acceleration at $L_{CG}$, expressed in g, defined in [3.3.4].
3.3.4 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) 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.

### Table 4: Longitudinal slamming pressure distribution factor \( K_1 \)

<table>
<thead>
<tr>
<th>Location</th>
<th>( K_1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>from ait part to 0.25 ( L_{WL} )</td>
<td>0.60</td>
</tr>
<tr>
<td>from 0.25 ( L_{WL} ) to 0.70 ( L_{WL} )</td>
<td>0.90</td>
</tr>
<tr>
<td>from 0.70 ( L_{WL} ) to 0.85 ( L_{WL} )</td>
<td>1.00</td>
</tr>
<tr>
<td>from 0.85 ( L_{WL} ) to fore part</td>
<td>0.75</td>
</tr>
</tbody>
</table>

### 3.3.5 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 service and the navigation notation as defined in Ch 1, Sec 1, [1.1.3]:

\[
a_{CG} = \text{foc} \cdot \text{soc} \cdot \frac{V}{\sqrt{L_{WL}}}
\]

where:

\( \text{foc, soc} \) : Values given, respectively, in Tab 5 and Tab 6.
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:

$$a_{CG} = \frac{(50 - \alpha_{dCG})/16 \times (H_S/\tau + 0,084 B_W/T)}{3555 C_T} K_{FR} K_{HS}$$

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

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

Table 5 : Values of foc

<table>
<thead>
<tr>
<th>Type of service</th>
<th>Passenger, Ferry, Cargo</th>
<th>Supply, Fishing</th>
<th>Pilot, Patrol</th>
<th>Rescue</th>
</tr>
</thead>
<tbody>
<tr>
<td>foc</td>
<td>0,666</td>
<td>1,000</td>
<td>1,333</td>
<td>1,666</td>
</tr>
</tbody>
</table>

Note 1: As a rule, foc is to be taken equal to 0,666 for launch and sea going launch.

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

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

Table 6 : Values of soc

<table>
<thead>
<tr>
<th>Navigation notation (for information only)</th>
<th>Unrestricted navigation</th>
<th>Summer zone</th>
<th>Tropical zone or coastal area (3)</th>
<th>Sheltered area (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave height</td>
<td>$H_S \geq 4,0 \text{m or } 2,5 \leq H_S &lt; 4,0 \text{m}$</td>
<td>$0,5 \leq H_S &lt; 2,5 \text{m}$</td>
<td>$H_S \leq 0,5 \text{m}$</td>
<td></td>
</tr>
<tr>
<td>soc</td>
<td>$C_T$ (2)</td>
<td>0,30</td>
<td>0,23</td>
<td>0,14</td>
</tr>
</tbody>
</table>

(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) For passenger, ferry and cargo ship, their seaworthiness in this condition is to be ascertained. In general, the value of soc should not be less than the values given in this Table, with:

$$C_T = 0,2 + \frac{0,6}{V/\sqrt{L_{WL}}} \geq 0,32$$

(3) Not applicable to ships having the type of service “Rescue”.

(4) Not applicable to ships having the type of service “Pilot, Patrol” or “Rescue”.

As a rule, applicable to ships having the navigation notation sea going launch or launch.
SECTION 4  LOCAL INTERNAL PRESSURES AND FORCES

Symbols

\[ \text{LWL} : \text{Length at waterline at full load, in m} \]
\[ \text{LHULL} : \text{Length of the hull from the extreme forward part to the extreme aft part of the hull, in m} \]
\[ \text{LW} = 0.5 (\text{LWL} + \text{LHULL}) \]
\[ \text{CW} = 0.625 (118 - 0.36 \text{LW}) \cdot 10^{-3} \]
\[ \text{B} : \text{Moulded breadth, in m, as defined in Ch 1, Sec 1, [4.3.1]} \]
\[ \text{BWL} : \text{Waterline breadth, in m, as defined in Ch 1, Sec 1, [4.3.2]} \]
\[ \text{BE} : \text{Breadth between multihull floats, in m, as defined in Ch 1, Sec 1, [4.3.3]} \]
\[ \text{BSF} : \text{Moulded breadth, in m, of the submerged float of swath, as defined in Ch 1, Sec 1, [4.3.4]} \]
\[ \text{CB} : \text{Total block coefficient as defined in Ch 1, Sec 1, [4.6]} \]
\[ \text{n} : \text{Navigation coefficient as defined in Ch 1, Sec 1, [3]} \]
\[ \text{V} : \text{Maximum ahead service speed, in knots} \]
\[ \text{g} : \text{Gravity acceleration taken equal to 9.81 m/s}^2 \]
\[ \text{a}_{\text{z}} : \text{Vertical acceleration, in m/s}^2, \text{defined in [2.2]} \]
\[ \text{A} : \text{Sea water density, taken equal to 1.025 t/m}^3 \]

1 Application

1.1 General

1.1.1 The local internal pressures and forces are based on the ship accelerations calculated on the basis of the present Section.

1.1.2 Definition

Local internal pressures are loads induced by liquid cargoes, dry cargoes, accommodations, wheeled loads when applicable, testing loads and flooding loads.

1.1.3 Planing hull

As a rule, the local internal pressures and forces for planing hull are to be calculated taking into account the accelerations in planing hull mode condition and in displacement hull mode condition.

2 Ship accelerations

2.1 Reference values

2.1.1 The reference values of the vertical and transverse accelerations, and the amplitude taken into account in the present Section are considered equal to the values given in the present Article.

2.1.2 As an alternative, the Society may accept the values of ship accelerations derived from direct calculations or obtained from model tests, when justified on the basis of the ship characteristics and the intended service.

2.1.3 The motions and accelerations are defined:

- in displacement mode: in [2.1.4] to [2.1.7] and in [2.2.1]
- in planing mode: in [2.2.2].

2.1.4 Motion and acceleration parameter

The motions and accelerations are based on a parameter \( a_{\text{B}} \) to be taken equal to:

\[ a_{\text{B}} = n \left( 0.76F + 2,5 \frac{\text{CW}}{\text{LWL}} \right) \]

where:

\[ F : \text{Froude’s number equal to:} \]
\[ F = 0, 164 \left( \frac{V}{\sqrt{\text{A}_p}} \right) \leq 0, 33 \]

Note 1: At a preliminary design stage when \( V \) is unknown, \( F \) may be taken equal to 0.33.

2.1.5 Heave

The heave acceleration \( a_{\text{H}} \), in m/s\(^2\), is obtained from the following formulae:

- for cargo ships: \( a_{\text{H}} = a_{\text{B}} g \)
- for non cargo ships: \( a_{\text{H}} = 1.25 a_{\text{B}} g \)

2.1.6 Pitch

The pitch acceleration \( \alpha_{p} \), in rad/s\(^2\), is obtained from the following formula:

\[ \alpha_{p} = A_{p} \left( \frac{2\pi}{T_p} \right)^2 n \]

where:

\[ A_{p} : \text{Pitch amplitude } A_{p}, \text{ in rad, equal to:} \]
\[ A_{p} = (1 - \text{LWL} \cdot 10^{-3}) C_{A_{p}} \]

with:

- for cargo ships:
  \( C_{A_{p}} = 0.14 \) for monohull
  \( C_{A_{p}} = 0.16 \) for catamaran
  \( C_{A_{p}} = 0.21 \) for swath
- for non cargo ships:
  \( C_{A_{p}} = 0.16 \) for monohull
  \( C_{A_{p}} = 0.16 \) for catamaran
  \( C_{A_{p}} = 0.21 \) for swath
\( T_p \): Pitch period, in s:

- for cargo ships:
  \[ T_p = 0.56 \left( \frac{LWL}{0.5} \right) \]
- for non cargo ships:
  \[ T_p = 0.51 \left( \frac{LWL}{0.5} \right) \]

\( T_p \): Roll period, in s, equal to:

- for cargo ships:
  \[ GM = 0.13 BWL \quad \text{and} \quad \delta = 0.35 B \]
- for catamaran:
  \[ GM = 1.10 B_t \quad \text{and} \quad \delta = (0.3 B_t BWL)^{0.5} \]
- for swath:
  \[ GM = 0.50 B_t \quad \text{and} \quad \delta = (0.3 B_t BWL)^{0.5} \]

\( a_h \): Roll amplitude, in rad:

- for cargo ships:
  \[ a_h = 0.35 \quad \text{for monohull} \]
  \[ a_h = 0.17 \quad \text{for catamaran} \]
  \[ a_h = 0.08 \quad \text{for swath} \]

- for non cargo ships:
  \[ a_h = 0.43 \quad \text{for monohull} \]
  \[ a_h = 0.17 \quad \text{for catamaran} \]
  \[ a_h = 0.08 \quad \text{for swath} \]

\( T_k \): Roll period, in s, equal to:

\[ T_k = 2.2 \frac{\delta}{\sqrt{GM}} \]

- for cargo ships:
  - for monohull:
    \[ GM = 0.13 BWL \quad \text{and} \quad \delta = 0.35 B \]
  - for catamaran:
    \[ GM = 1.10 B_t \quad \text{and} \quad \delta = (0.3 B_t BWL)^{0.5} \]
  - for swath:
    \[ GM = 0.50 B_t \quad \text{and} \quad \delta = (0.3 B_t BWL)^{0.5} \]

- for non cargo ships:
  - for monohull:
    \[ GM = 0.22 BWL \quad \text{and} \quad \delta = 0.35 B \]
  - for catamaran:
    \[ GM = 1.10 B_t \quad \text{and} \quad \delta = (0.3 B_t BWL)^{0.5} \]
  - for swath:
    \[ GM = 0.50 B_t \quad \text{and} \quad \delta = (0.3 B_t BWL)^{0.5} \]

### 2.2 Vertical accelerations

#### 2.2.1 Cargo and non cargo ship

The vertical acceleration \( a_z \), in m/s\(^2\), to be taken into account in relation to the ship location areas is to be as defined in Tab 1.

<table>
<thead>
<tr>
<th>Location</th>
<th>Cargo ship</th>
<th>Non cargo ship</th>
</tr>
</thead>
<tbody>
<tr>
<td>from aft part to 0.25 LWL</td>
<td>( \sqrt{a_H^2 + a_{CG}^2(0, 40LWL)^2} )</td>
<td>( \sqrt{a_H^2 + a_{CG}^2(0, 30LWL)^2} )</td>
</tr>
<tr>
<td>from 0.25 LWL to 0.70 LWL</td>
<td>( \sqrt{a_H^2 + a_{CG}^2(0, 20LWL)^2} )</td>
<td>( \sqrt{a_H^2 + a_{CG}^2(0, 20LWL)^2} )</td>
</tr>
<tr>
<td>from 0.70 LWL to 0.85 LWL</td>
<td>( \sqrt{a_H^2 + a_{CG}^2(0, 40LWL)^2} )</td>
<td>( \sqrt{a_H^2 + a_{CG}^2(0, 30LWL)^2} )</td>
</tr>
<tr>
<td>from 0.85 LWL to fore part</td>
<td>( \sqrt{a_H^2 + a_{CG}^2(0, 55LWL)^2} )</td>
<td>( \sqrt{a_H^2 + a_{CG}^2(0, 50LWL)^2} )</td>
</tr>
</tbody>
</table>

#### 2.2.2 Planing hull

The vertical acceleration \( a_z \), in m/s\(^2\), to be taken into account in relation to the ship location for planing hull in planing mode is to be taken equal to the following values:

a) At speed in displacement mode:

\[ a_z = g \alpha_v \]

where:

\[ \alpha_v = K_v a_{CG} \]

with:

- \( K_v \): As defined in Tab 2
- \( a_{CG} \): Design vertical acceleration at \( L_{CG} \) as defined in Sec 3, [3.3.4]
- \( L_{CG} \): Midship perpendicular as defined in Ch 1, Sec 1, [4.2.3].

<table>
<thead>
<tr>
<th>Location</th>
<th>( K_v )</th>
</tr>
</thead>
<tbody>
<tr>
<td>from aft part to 0.25 LWL</td>
<td>1.00</td>
</tr>
<tr>
<td>from 0.25 LWL to 0.70 LWL</td>
<td>1.20</td>
</tr>
<tr>
<td>from 0.70 LWL to 0.85 LWL</td>
<td>1.55</td>
</tr>
<tr>
<td>from 0.85 LWL to fore part</td>
<td>1.85</td>
</tr>
</tbody>
</table>

### 3 Internal loads

#### 3.1 Liquids

##### 3.1.1 Watertight bulkheads

The local internal pressure p, in kN/m\(^2\), on watertight bulkheads, bottom and top of liquid capacity is to be taken equal to the greater value obtained from the following formulae:

\[ p = \rho \left[ 0.15g \frac{\delta}{2} + a_n (z_{TOP} - z) + g(x_L - z) \right] \]

\[ p = \rho (g + a_n)(z_{TOP} - z) + 100p_{ps} + 0.15ng\frac{\delta}{2} \]
Figure 1: z co-ordinates

where:

- \( \rho_L \): Density of the liquid considered, in t/m³
- \( a_z \): Vertical acceleration, in m/s², as defined in [2.2]
- \( \lambda_b \): Longitudinal distance, in m, between the transverse capacity boundaries or the transverse swash bulkheads, if any, satisfying the requirements in [3.1.2]
- \( \eta \): Acceleration coefficient to be taken equal to:
  - for ship in displacement mode: \( \eta = 0,8 \)
  - for ship in planing mode: \( \eta = 0,4 \)
- \( z_{TOP} \): z co-ordinate, in m, of the highest point of the capacity (see Fig 1)
- \( z \): z co-ordinate of the calculation point, as defined in Sec 1, [4]
- \( p_{sv} \): Setting pressure, in bar, of safety valves, if any

\[ z_L = z_{TOP} + 0,5 \left( z_{AP} - z_{TOP} \right) \]

with:

- \( z_{AP} \): z co-ordinate, in m, of the top of air pipe (see Fig 1).

### 3.1.2 Swash bulkheads

The local internal pressure \( p \), in kN/m², acting on swash bulkheads is obtained as follows:

- for transverse swash bulkheads:
  \[ p = 4,4 \rho_L n \ell_c (1 - \alpha) 0,15 \]
- for longitudinal swash bulkheads:
  \[ p = 4,4 \rho_L n b_c (1 - \alpha) 0,35 \]

with \( p \geq 0,8 \) g \( d_0 \)

where:

- \( \rho_L \): Density of the liquid considered, in t/m³
- \( \ell_c \): Longitudinal distance, in m, between transverse bulkheads (watertight or swash)
- \( b_c \): Transverse distance, in m, between longitudinal bulkheads (watertight or swash)
- \( \alpha \): Ratio of lightening hole area to the total bulkhead area, not to be taken greater than 0,3
- \( d_0 \): Distance, in m, to be taken equal to:
  \[ d_0 = 0,02 L \leq 1,00 \]

### 3.2 Dry cargoes

#### 3.2.1 Dry uniform cargo

The pressure \( p \), in kN/m², transmitted to the structure by dry uniform cargo is to be taken equal to the following formula:

\[ p = p_s \left( 1 + \frac{\eta a_z}{g} \right) \]

where:

- \( p_s \): Design pressure given by the Designer
- \( \eta \): Acceleration coefficient to be taken equal to:
  - for ship in displacement mode: \( \eta = 1,0 \)
  - for ship in planing mode: \( \eta = 0,4 \)

#### 3.2.2 Dry bulk cargo

The pressure \( p \), in kN/m², transmitted to the structure by dry bulk cargo is to be taken equal to the greater value obtained from the following formulae:

\[ p = p_s \left( 1 + \frac{\eta a_z}{g} \right) \]

\[ p = \rho_B (g + a_z \eta) (h_b + h_c - h_s) K_B \]

where:

- \( \rho_B \): Density of the dry bulk carried, in t/m³
- \( p_{DB} \): Design pressure on the double bottom, in kN/m², given by the Designer
- \( a_z, \eta \): As defined in [3.2.1]
- \( h_b \): Height, in m, from the bottom cargo hold, of the rated surface of the bulk, to be taken equal to:
  \[ h_b = \frac{M_c}{K_B} \]

with:

- \( M_c \): Total mass of cargo, in t, in the considered hold
- \( \ell_c \): Longitudinal distance, in m, between transverse hold bulkheads
- \( b_c \): Transverse distance, in m, between longitudinal hold bulkheads
hₜ : Height, in m, of the bulk cargo upper surface, to be taken equal to:
  \[ h_t = \frac{b}{4} \tan \frac{\varphi}{2} \]

with:
\( \varphi \): Angle of repose, in deg, of the bulk cargo considered drained and removed (in absence of precise evaluation, \( \varphi \) may be taken equal to 30°)

hᵥ : Vertical distance, in m, from the bottom hold to the calculation point

Kₖ : Coefficient, taken equal to:
- \( K_k = 0.4 \) when the dry bulk pressure is applied on a vertical structure element
- \( K_k = 1.0 \) in the other cases.

### 3.2.3 Dry unit cargo

The forces transmitted to the hull structures are to be determined on the basis of the forces \( F_z \), in kN, calculated as follows:

\[ F_z = M (g + a_z \eta) \]

where:
\( a_z \): Reference value of the vertical acceleration defined in [2.2]
\( M \): Total mass, in t, of the dry unit cargo considered
\( \eta \): As defined in [3.2.1].

Where deemed necessary by the Society for dry unit cargo located above the water line level, the horizontal and vertical forces applied to the dry unit cargo, in kN, induced by roll may be taken into account in addition to \( F_z \).

In this case, the forces \( F_T \) and \( F_V \), in kN, transmitted to the hull structure and to be added to \( F_z \) may be calculated as follows:

- transverse force:
  \[ F_T = 0.7 \, M \, \alpha_r (z - T_{\text{min}}) \]

- vertical force:
  \[ F_V = 0.7 \, M \, \alpha_r \, y \]

where:
\( M \): Mass, in t, of the dry unit cargo considered
\( \alpha_r \): Roll acceleration, in m/s², as defined in [2.1.7]
\( y, z \): Transverse and vertical co-ordinates of the centre of gravity of the dry unit considered
\( T_{\text{min}} \): Minimum draught of the ship, in m.

### 3.3 Wheeled loads

#### 3.3.1 Local forces

Caterpillar trucks and unusual vehicles are considered by the Society on a case-by-case basis.

The load supported by the crutches of semi-trailers, handling machines and platforms is considered by the Society on a case-by-case basis.

The forces transmitted through the tyres are comparable to the pressure uniformly distributed on the tyre print, the dimensions of which are to be indicated by the Designer together with the information concerning the arrangement of wheels on axles, the load per axle and the tyre pressures.

For vehicles on rails, all the forces transmitted are to be considered as concentrated.

The forces \( F_W \), in kN, transmitted to the hull structure are to be determined as follows:

- in the general case:
  \[ F_W = M \, (g + \alpha \, a_z) \]

- in harbour conditions, for fork-lift trucks and vehicles on external ramp:
  \[ F_W = 1.1 \, M \, g \]

where:
\( M \): Force, in t, applied by one wheel and calculated as follows:

\[ M = \frac{Q_A}{n_W} \]

with:
\( Q_A \): Axle load, in t. For fork-lift trucks, \( Q_A \) is to be taken equal to the total mass of the vehicle, including the mass of the cargo handled, applied to one axle only
\( n_W \): Number of wheels for the axle considered
\( \alpha \): Coefficient taken equal to:
- in the general case: \( \alpha = 0.5 \)
- for landing gears of trailers: \( \alpha = 1.0 \)
\( a_z \): Reference value of the vertical acceleration defined in [2.2].

### 4 Loads on deck

#### 4.1 Exposed deck

4.1.1 The local external loads, in kN/m², on exposed deck are to be as defined in Sec 3, [2.2.2].

<table>
<thead>
<tr>
<th>Table 3 : Minimum values of ( p_s )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accommodation deck</strong></td>
</tr>
<tr>
<td>Large public spaces such as restaurants, halls, cinema, lounges</td>
</tr>
<tr>
<td>Large rooms such as rooms with fixed furniture, games and hobbies rooms, hospitals</td>
</tr>
<tr>
<td>Cabins</td>
</tr>
<tr>
<td>Other compartments</td>
</tr>
</tbody>
</table>
## Table 4: Testing load values

<table>
<thead>
<tr>
<th>Compartment or structure to be tested</th>
<th>Still water pressure $p_{ST}$, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Double bottom tanks</strong></td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + d_{AP}$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 2,4$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{BD} - z \right)$</td>
</tr>
<tr>
<td><strong>Double side tanks</strong></td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + d_{AP}$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 0,3H$ (1)</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{BD} - z \right)$</td>
</tr>
<tr>
<td><strong>Deep tanks other than those listed elsewhere in this Table and independent tanks</strong></td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + d_{AP}$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 0,3H$ (1)</td>
</tr>
<tr>
<td><strong>Cargo oil tanks</strong></td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + d_{AP}$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 2,4$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 10$ $p_{PV}$</td>
</tr>
<tr>
<td><strong>Ballast holds of ships with service notation bulk carrier or bulk carrier ESP</strong></td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + d_{AP}$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 2,4$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 10$ $p_{PV}$</td>
</tr>
<tr>
<td><strong>Peak tanks</strong></td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + d_{AP}$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 0,3H$ (1)</td>
</tr>
<tr>
<td><strong>Chain locker</strong></td>
<td>$p_{ST} = 10 \left( z_{CP} - z \right)$</td>
</tr>
<tr>
<td>where:</td>
<td>where:</td>
</tr>
<tr>
<td>$z_{CP}$ : Z co-ordinate, in m, of the top of chain pipe</td>
<td></td>
</tr>
<tr>
<td><strong>Ballast ducts</strong></td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 10$ $p_{PV}$</td>
</tr>
<tr>
<td></td>
<td>the ballast pump maximum pressure</td>
</tr>
<tr>
<td><strong>Integral or independent cargo tanks of ships with service notation chemical tanker</strong></td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 2,4$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 10$ $p_{PV}$</td>
</tr>
<tr>
<td><strong>Fuel oil tanks</strong></td>
<td>The greater of the following:</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + d_{AP}$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 0,3H$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{TOP} - z \right) + 10$ $p_{PV}$</td>
</tr>
<tr>
<td></td>
<td>$p_{ST} = 10 \left( z_{BD} - z \right)$</td>
</tr>
<tr>
<td><strong>Note 1:</strong></td>
<td></td>
</tr>
<tr>
<td>$z_{TOP}$ : Z co-ordinate, in m, of the deck forming the top of the tank excluding any hatchways.</td>
<td></td>
</tr>
<tr>
<td>$z$ : z co-ordinate of the calculation point</td>
<td></td>
</tr>
<tr>
<td>$d_{AP}$ : Distance, in m, from the top of air pipe to the top of the compartment</td>
<td></td>
</tr>
<tr>
<td>$p_{PV}$ : Setting pressure, in bar, of the safety relief valves, where relevant.</td>
<td></td>
</tr>
<tr>
<td>(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 ships greater than 40 m, 0,3H is to be taken equal to 2,4 m.</td>
<td></td>
</tr>
</tbody>
</table>
4.2 Accommodation deck

4.2.1 The pressure on accommodation deck is obtained, in kN/m², from the following formula:

\[ p = p_s \left( 1 + \frac{a_x \eta}{g} \right) \]

where:
- \( a_x \) : Reference value of the vertical acceleration defined in [2.2]
- \( \eta \) : As defined in [3.2.1]
- \( p_s \) : Pressure defined by the Designer, to be taken at least equal to the values given in Tab 3.

4.3 Specific loads on deck

4.3.1 Specific loads on deck such as wheeled loads, dry unit cargo, containers, are to be determined as defined in Article [3].

4.3.2 Machinery spaces

The pressure on decks and platforms located in the machinery spaces is obtained, in kN/m², from the following formula:

\[ p = p_s \left( 1 + \frac{a_x \eta}{g} \right) \]

where:
- \( a_x \) : Reference value of the vertical acceleration defined in [2.2]
- \( \eta \) : As defined in [3.2.1]
- \( p_s \) : Pressure defined by the Designer

When this value is not defined, \( p_s \) may be taken equal to 10 kN/m².

5 Testing loads

5.1 General

5.1.1 The testing loads acting on the structures subject to tank testing are obtained, in kN/m², from the formulae in Tab 4.

Compartments not defined in Tab 4 are to be tested in accordance with NR467 Steel Ships, Pt B, Ch 5, Sec 6.

6 Flooding loads

6.1 General

6.1.1 The internal pressure \( p_{fl} \) to be considered on the structure of boundaries of watertight compartments not intended to carry liquids (bulkheads and decks with exception for bottom and side shell structures) is to be obtained, in kN/m², from the following formula:

\[ p_{fl} = 1.5 \rho g n d_f \]

without being taken less than 0.8 \( g d_0 \)

where:
- \( d_f \) : Distance, in m, from the calculation point to the bulkhead deck (or freeboard deck 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
- \( d_0 \) : Distance, in m, to be taken equal to:
  - \( d_0 = 1 \) if \( LWL \leq 50 \text{ m} \)
  - \( d_0 = 0.02 LWL \) if \( LWL > 50 \text{ m} \)
Chapter 4

HULL SCANTLING

SECTION 1  GENERAL
SECTION 2  GLOBAL STRENGTH ANALYSIS
SECTION 3  LOCAL PLATING SCANTLING
SECTION 4  LOCAL SECONDARY STIFFENER SCANTLING
SECTION 5  LOCAL PRIMARY STIFFENER SCANTLING
SECTION 6  STIFFENER BRACKETS SCANTLING AND STIFFENER END CONNECTIONS
SECTION 7  PILLAR SCANTLING
APPENDIX 1  CALCULATION OF THE CRITICAL BUCKLING STRESSES
APPENDIX 2  HULL SCANTLING CHECK WITH LOCAL AND GLOBAL STRESSES COMBINATION CRITERIA
SECTION 1  GENERAL

1  Materials

1.1  General

1.1.1  General
The requirements for the determination of the hull scantlings defined in the present Chapter are applicable to ship hull made totally or partly of:
- steel (ordinary or high tensile)
- aluminium alloys
- composites materials
- wood (strip planking or plywood).

Ships built with different hull materials are to be specifically considered on a case-by-case basis.

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.

1.1.2  Characteristics of materials
The main characteristics of materials to consider for hull scantlings are defined in Ch 1, Sec 2.

2  Structure scantling approach

2.1  General

2.1.1  General case
As a rule, the global hull girder strength and the local strength are examined independently.

2.1.2  Particular cases
The combination of global hull girder strength and the local strength may be carried out as defined in Ch 1, Sec 3, [2.1.2]. In this case, the requirements defined in NR467 Steel Ships, Chapter 7, dedicated for Cargo Ships greater than 65 m or Non Cargo Ships greater than 90 m, may be fully applied the Society.

2.2  Global strength analysis

2.2.1  Analysis
The global hull girder longitudinal strength and the global strength of multihull are to be checked according to Sec 2, taking into account the:
- global loads as defined in Ch 3, Sec 2, and
- permissible stresses and safety factors as defined in Ch 2, Sec 3.

2.2.2  Check
The global strength analysis is carried out in order to check, for the elements contributing to the global hull strength, the hull girder stresses in relation to:
- the maximum permissible global stress, and
- buckling criteria.

2.3  Local scantling analysis

2.3.1  Analysis
The local scantling of panels, secondary stiffeners and primary stiffeners is to be checked according to Sec 3 for plating, Sec 4 for secondary stiffeners and Sec 5 for primary stiffeners, taking into account the:
- local loads as defined in Ch 3, Sec 3 for external pressure, Ch 3, Sec 4 for internal pressure and Ch 5, Sec 1 for superstructures, and
- permissible stresses and safety factors as defined in Ch 2, Sec 3.

The type of local lateral pressures to be considered are:
- wave loads
- dynamic loads:
  - bottom slamming pressures for planing hull, when slamming may occur
  - side shell impacts (and platform bottom impacts for multihull) for all types of ships, where applicable (see Ch 3, Sec 3, [3.1])
- deck loads and superstructure pressures
- bulkhead and tank loads
- wheeled loads.

2.3.2  Check
The local strength analysis is carried out in order to check, for the plating, secondary and primary stiffeners, the local stresses in relation to:
- the maximum permissible local stress, and
- local buckling criteria, where applicable.

2.4  Specific cases

2.4.1  Specific scantling criteria in relation to the service notation of the ships are defined in Ch 6, Sec 1.
SECTION 2  GLOBAL STRENGTH ANALYSIS

1 General

1.1 Application

1.1.1 The global strength analysis is to be carried out in order to check the hull girder stress in relation to maximum permissible stress and buckling stress (see [2.2] and [2.3]).

1.1.2 Material

The global strength analysis of monohull and multihull is to be carried out taking into account:

- for steel structure: the present Section
- for aluminium structure: the present Section and NR561 Aluminium Ships
- for composite structure: the present Section and NR546 Composite Ships.

1.1.3 Application

a) Monohull ships and float of multihull:

For monohull ships and for floats of multihull, the global hull girder longitudinal strength is to be examined in the following cases:

- ships with length greater than 40 m, and 30 m for ship built in composite material, or
- ships having large openings in decks or significant geometrical structure discontinuity at bottom or deck, or
- ships with transverse framing systems, or
- ships with deck structure built with large spacing of secondary stiffeners, or
- cargo ship as defined in Ch 1, Sec 1, [2.1.2], or
- where deemed appropriate by the Society.

For ships not covered by the above cases, the hull girder strength is considered satisfied when local scantlings are in accordance with requirements defined in Sec 3 and in Sec 4.

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.

1.2 Global strength calculation

1.2.1 General

The global strength of monohull and multihull are to be calculated as defined in [3] and [4].

1.2.2 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 \(10^5 \text{ N/mm}^2\), the steel equivalent sectional area that may be included for the calculation of the inertia of the considered section is obtained, in m², from the following formula:

\[
A_{st} = \frac{E}{2.06 \cdot 10^5} \cdot A_w
\]

where:

- \(A_w\) : Sectional area, in m², of the member under consideration
- \(E\) : Young modulus, in N/mm², of the considered member.

1.2.3 Finite element calculation

The global strength analysis may also be examined with a Finite Elements Analysis submitted by the Designer. In this case, and where large openings are provided in side shell and/or in primary transverse cross structure of platform of multihull for windows, doors..., a special attention is to be paid to ensure a realistic modelling of the bending and shear strength of the jambs between openings.

2 Global strength check

2.1 General

2.1.1 The global analysis check is to be successively carried out taking into account the scantling criteria based on maximum stress check (see [2.2]) and on buckling check (see [2.3]).

The global analysis check is to be carried out in the following areas of the hull:

- in head sea condition (for monohull and multihull):
  - Along the ship from 0.3L to 0.7L from the aft end
- in quartering sea (for multihull only):
  - Along the float from aft to fore end, and in way of each primary transverse cross structure of the platform.

2.2 Maximum stress check

2.2.1 Steel and aluminium structure

It is to be checked that the actual normal stresses \(\sigma_n\) in N/mm², and the actual shear stresses \(\tau_n\) in N/mm², calculated according to [3] and, for multihull, to [4] are in compliance with the following criteria:

\[
|\sigma_n| \leq \sigma_{glam}
\]

\[
|\tau_n| \leq \tau_{glam}
\]

where:

- \(\sigma_{glam}\) : Global bending permissible stress, in N/mm², as defined in Ch 2, Sec 3
- \(\tau_{glam}\) : Global shear permissible stress, in N/mm², as defined in Ch 2, Sec 3.
2.2.2 Composite structure

It is to be checked that the actual normal stresses and shear stresses, calculated according to [3] and, for multihull, to [4] are in compliance with the criteria defined in Ch 2, Sec 3, [3.1].

2.3 Buckling check

2.3.1 Plate panel

a) Steel and aluminium plate panel:

It is to be checked that the actual normal stresses $\sigma_A$ and shear stresses $\tau_A$ calculated according to Article [3] and, for multihull, to Article [4] are in compliance with the following criteria:

- under simple compression:
  \[ |\sigma_A| \leq \frac{\sigma_c}{S_F} \]
- under double compression and shear (for platform bottom and deck of catamaran):
  \[ \frac{\sigma_A^9}{\sigma_{c,a}^9} + \frac{\sigma_A^9}{\sigma_{c,b}^9} + \frac{\tau_A^9}{\tau_c^9} \leq 1 \]
- under shear:
  \[ |\tau_A| \leq \frac{\tau_c}{S_F} \]

where:

- $\sigma_c$, $\tau_c$ : Critical buckling stress, in N/mm$^2$, in compression and in shear as defined in App 1 for steel plating and in NR561 Aluminium Ships for aluminium plating
- SF : Permissible safety factor defined in Ch 2, Sec 3, [2]
- $\sigma_{c,a}$, $\sigma_{c,b}$ : Critical buckling stresses, in N/mm$^2$, in double compression as defined in App 1 for steel plating and in NR561 Aluminium Ships for aluminium plating
- $\sigma_B$ : Actual compression stress acting on side “b”, in N/mm$^2$

b) Plate panel in composite material:

It is to be checked that the actual normal stresses $\sigma_A$ and shear stresses $\tau_A$ calculated according to Article [3] and, for multihull, to Article [4] are in compliance with the following criteria:

\[ |\sigma_A| \leq \frac{\sigma_c}{S_F} \]
\[ |\tau_A| \leq \frac{\tau_c}{S_F} \]

where:

- $\sigma_c$, $\tau_c$ : Critical buckling stress, in N/mm$^2$, in compression and in shear in the whole panel as defined in NR546 Composite Ships (Sec 6, [4])
- SF : Permissible safety factor defined in Ch 2, Sec 3, [3.2.3].

2.3.2 Secondary stiffeners

As a rule, the buckling check is to be carried out for stiffeners parallel to the direction of compression only.

It is to be checked that the actual normal stresses $\sigma_A$ calculated according to Article [3] and, for multihull, to Article [4] is in compliance with the following criteria:

\[ |\sigma_A| \leq \frac{\sigma_c}{S_{FB}} \]

where:

- $\sigma_c$ : Critical buckling stress, in N/mm$^2$, in compression as defined in:
  - App 1 for stiffeners in steel
  - NR561 Aluminium Ships for stiffeners in aluminium
  - NR546 Composite Ships for stiffeners in composite materials
- SF : Permissible rule safety factors defined in Ch 2, Sec 3, [2] for steel and aluminium stiffeners, and in Ch 2, Sec 3, [3.2.3] for composite stiffeners.

2.3.3 Primary stiffeners

The buckling check for primary stiffeners is to be carried out as defined in [2.3.2] for secondary stiffeners.

3 Calculation of global strength for monohull ship

3.1 General

3.1.1 The calculation of the hull girder strength characteristics 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 be considered as contributing to the longitudinal strength.

The transverse 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 deducted from the considered transverse section.

Lightening holes, draining holes and single scallops in longitudinal stiffeners need not be deducted 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.
3.2 Strength characteristics

3.2.1 Section modulus

The section modulus in any point of a transverse section along the hull girder is given, in m³, by the following formula:

\[ Z_A = \frac{I_Y}{z - N} \]

where:
- \( I_Y \): Moment of inertia, in m⁴ of the transverse section considered, calculated taking into account all the continuous structural elements of the hull contributing to the longitudinal strength as defined in [3.1], with respect to the horizontal neutral axis
- \( z \): Z co-ordinate, in m, of the considered point in the transverse section above the base line
- \( N \): Z co-ordinate, in m, of the centre of gravity of the transverse section, above the base line.

3.2.2 Section moduli at bottom and deck

The section moduli at bottom and deck are given, in m³, 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 [3.2.1]
- \( V_D \): 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.

3.2.3 Shear transverse section

As a rule, the total shear section \( S_v \) of a transverse section along the hull girder may be considered as equal to the sum of the vertical sections of the side shells and of the longitudinal bulkheads contributing to the global strength of the hull girder.

3.3 Overall stresses

3.3.1 Longitudinal bending stresses

a) The actual overall longitudinal bending stress \( \sigma_A \) in any point of a transverse section, in N/mm², is obtained by the following formula:

\[ \sigma_A = \frac{M_v}{Z_A} \times 10^{-3} \]

where:
- \( M_v \): Vertical overall bending moment of combination global loads in head sea conditions, in kN-m, as defined in Ch 3, Sec 2, [3] and for planing hull as defined in Ch 3, Sec 2, [6.1]
- \( Z_A \): Section modulus, in m³, calculated according to [3.2.1].

b) The actual overall longitudinal bending stress in a member made in material other than steel with a Young’s modulus \( E \) equal to 2.06 \( 10^5 \) N/mm² is obtained from the following formula:

\[ \sigma_{AS} = \frac{E}{2 \times 0.6 \times 10^5} \sigma_A \]

where:
- \( \sigma_{AS} \): Actual overall longitudinal bending stress, in N/mm² in the member under consideration, calculated according to a) considering this member having the steel equivalent sectional area \( A_{SE} \) defined in [1.2.2].

3.3.2 Vertical shear stresses

The actual vertical shear stress \( \tau_A \) in any point of a section, in N/mm², is obtained by the following formula:

\[ \tau_A = \frac{Q_v S_v V}{I_y t} \times 10^{-3} \]

where:
- \( Q_v \): Vertical overall shear force of combination global loads in head sea conditions, in kN, as defined in Ch 3, Sec 2, [3]
- \( S_v \): Vertical section, in m², calculated according to [3.2.3].

When deemed necessary, it may be possible to calculate the shear stress at any point of a section as follows:

\[ \tau_a = \frac{Q_s S_v V}{I_y t} \]

where:
- \( S_v \): Vertical section, in m², located above the point considered in the section
- \( V \): 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 [3.2.1]
- \( t \): Thickness, in mm, of the element where the shear stress is calculated.

4 Calculation of global strength for multihull

4.1 General

4.1.1 Type of global strength approach for multihull

The global strength of multihull is to be successively examined:

- in head sea conditions, according to Article [3]
- in quartering sea and in digging in waves conditions, according to [4.3]
- in addition for swath, in transverse bending moment, according to [4.4].
- in addition for planing hull, according to [4.5]

The global strength of multihull having more than two floats is to be examined on a case-by-case basis.
4.2 Global strength in head sea condition

4.2.1 General

The global strength in head sea condition is to be checked as defined in Article [3].

The moment of inertia $I_Y$ is to be calculated for only one float. A platform extending in length over at least 0.4 $L_{WL}$ is to be considered for the calculation of the inertia of the float with a breadth $b_R$ and $b_WD$ as defined in Fig 1, limited to 10% of the platform longitudinal length.

For swath, struts extending in length over at least 0.4 $L_{WL}$ is to be considered for the calculation of the inertia of the float.

4.3 Global strength in quartering sea and in digging in waves

4.3.1 General

The global strength of multihull in quartering sea is to be examined according to:

- the present sub article for multihull built in steel material
- the present sub article and NR561 Aluminium Ships for multihull built in aluminium alloys
- the present sub article and NR546 Composite Ships for multihull built in composite materials.

The global strength analysis may be carried out by a beam model as shown in Fig 2, taking into account the bending and shear stiffness of the primary transverse cross structure of the platform and of one float.

The transverse cross beams are fixed in the model in way of the inner side shell of the other float.

Any other justified global analysis submitted by the Designer may be considered.

4.3.2 Primary transverse cross structure model

Each primary transverse cross structure in the platform is considered as a beam in the global model, taking into account:

- its bending inertia about an horizontal axis (depending mainly on the web height of the transverse cross beam or bulkhead, and the thickness of the bottom and deck platform)
- its vertical shear inertia (depending on the web height of the transverse cross beams or bulkheads and their thickness)
- its span between inner side shell of floats.

4.3.3 Float model

The float is modelled as a beam having, as far as practicable:

- vertical and horizontal bending inertia, and
- a shear inertia, and
- a torsional inertia about longitudinal float axis close to the actual float values.

4.3.4 Loading of the model

The two following loading cases are to be considered:

- Loads in quartering sea condition as shown on Fig 3, where the torsional moment exerted on the platform and induced by encountered waves in quartering sea is represented by two vertical forces $F$ defined in Ch 3, Sec 2, [5.3.2].

  Note 1: As a general rule, two successive loading cases are to be taken into account: the case as shown in Fig 3 and the same case with forces in opposite direction.

- Loads in digging in waves condition as shown on Fig 4, where the torsional moment induced by the digging in wave is represented by the vertical forces $F_{VD}$ and horizontal forces $F_{HD}$ in kN, equal to:

  $$F_{VD} = F_{vm} - F_{vl}$$
  $$F_{HD} = F_{hm} - F_{hl}$$

  where:

  $F_{vm}$, $F_{vl}$, $F_{hm}$, $F_{hl}$: Fore float loads defined in Ch 3, Sec 2, [6.2.1] b)

  The vertical and horizontal linear loads $F_{VD}$ and $F_{HD}$ are to be applied from the fore part of the modelled 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.
4.3.5 Main structure check

The global bending moments and shear forces distribution in the float are as shown in Fig 5, and in the primary transverse cross structure as shown in Fig 6.

The bending stresses $\sigma$ and the shear stresses $\tau$ in the float and in the platform of the multihull are to be directly deduced from the beam model calculation and are to be in compliance with the criteria defined in Article [2].

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

Particular attention is to be paid to:

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

Figure 2: Model principle

Figure 3: Primary transverse cross structure of multihull - Loading in quartering sea condition

Figure 4: Primary transverse cross structure of multihull - Loading in digging in wave condition
4.4 Transverse bending moment acting on twin-hull connections of swath

4.4.1 The global transversal strength analysis of the primary structure of the platform of swath is to be carried out by a direct calculation.

The bending moment \( M_Q \), in kN.m, and the shear force \( F_Q \), in kN, applied along the platform structure of swath is to be taken equal to:

\[ M_Q = h_m \cdot F_Q \]

where:

\( h_m \) : Half the draught \( T \), in m, plus the distance from the waterline at draught \( T \) to the midpoint of the platform structure (see Ch 3, Sec 2, Fig 5)

\( F_Q \) : Beam side force, in kN, defined in Ch 3, Sec 2, [6.2.2].

The bending moment distribution is to be as shown on Fig 7. The shear force is to be considered as constant along the struts of the swath.

4.5 Global strength for planing hull

4.5.1 The global strength analysis of multihull planing hull is to be carried out:

a) In head sea condition:

according to [3.3] taking into account:

- Bending moments and shear forces defined in Ch 3, Sec 2, [6.1.1]
- A section modulus based on a moment of inertia \( I_y \) calculated for only one float. A platform extending in length over at least 0,4 \( L_{Wt} \) is to be considered for the calculation of the inertia of the float with a breadths \( b_R \) and \( b_{WD} \) as defined in Fig 1, limited to 10% of the platform longitudinal length.

b) In quartering sea conditions:

according to [4.3], in quartering sea only, taking into account the minimum transverse torsional moment along the float and in the platform defined in Ch 3, Sec 2, [6.1.2].
SECTION 3  LOCAL PLATING SCANTLING

Symbols

\( k \): Material factor, defined in Ch 1, Sec 2, [2] for steel and in Ch 1, Sec 2, [3] for aluminium alloys

\( s \): Length, in m, of the shorter side of the plate panel

\( \ell \): Length, in m, of the longer side of the plate panel

\( \mu \): Aspect ratio coefficient of the elementary plate panel, equal to:

\[ \mu = 1,21 \sqrt{1 + 0,33 \left( \frac{s}{\ell} \right)^2} - 0,69 \frac{s}{\ell} \leq 1 \]

\( \lambda \): Corrosion coefficient taken equal to:

- for steel plating: \( \lambda = 1,10 \)
- for aluminium plating: \( \lambda = 1,05 \)

\( \sigma_{\text{locam}} \): Local permissible bending stress, in N/mm\(^2\), as defined in Ch 2, Sec 3, in relation to the type of load

\( \tau_{\text{locam}} \): Local permissible shear stress, in N/mm\(^2\), as defined in Ch 2, Sec 3, in relation to the type of load.

1 General

1.1 General

1.1.1 The local plating scantling is to be carried out according to:

- for steel structure: the present Section
- for aluminium structure: the present Section and the NR561 Aluminium Ships
- for composite structure: the present Section and the NR546 Composite Ships.

1.1.2 The scantling of platings contributing to the overall longitudinal strength of the hull girder and to the overall transverse strength of transverse cross deck of multihull are also to be checked as defined in Sec 2.

1.2 Local loads

1.2.1 Local load types

The local lateral pressures to be considered are:

- for bottom platings: sea pressures, bottom slamming pressures (when slamming may occur for planing hull) and bottom impact pressures on flat bottom forward area when applicable
- for side shell and, for multihull, platform bottom platings: sea pressures and side shell impacts
- for deck platings: external or internal loads, minimum loads and, when applicable, wheeled loads
- for all platings, when applicable: internal pressure.

The platings subject to compression local loads are also to be checked against buckling criteria as defined in Sec 2, [2.3]. In this case, the value of \( \sigma_{\text{c}} \) considered in Sec 2, [2.3] is to be taken equal to the stress induced in the plate by the local loads.

1.2.2 Local load point calculation

The location of the point of the plating where the local loads are to be calculated in order to check the scantling are defined in:

- Ch 3, Sec 1, [4.1] for steel and aluminium plates
- Ch 3, Sec 1, [4.2] for composite panels
- Ch 3, Sec 1, [4.3] for superstructure panels.

2 Plating scantling

2.1 General

2.1.1 Loading cases and permissible stresses

The scantling of plating is obtained considering successively the different loads defined in [1.2.1] sustained by the plate (combined as defined in Ch 3, Sec 1, [3.1] if relevant), and the associated permissible stresses defined in Ch 2, Sec 3.

2.1.2 Deck plating protected by wood sheathing or deck composition

The thickness of deck plating protected by wood sheathing, deck composition or other arrangements deemed suitable by the Society may be reduced on a case by case basis. In any case this thickness is to be not less than the minimum value defined in [2.2.1].

The sheathing is to be secured to the deck to the satisfaction of the Society.

2.2 Scantling for steel and aluminium plating

2.2.1 Minimum thickness

a) As a rule, the thickness, in mm, of plates calculated according to the present Section are not to be less than:

- for steel plate:
  - cargo ship: 0,05 \( L \) \( W \) \( k^{1/2} \) + 3,5
  - non-cargo ship: 0,05 \( L \) \( W \) \( k^{1/2} \) + 3,0
  - sea-going launch and launch: 3,0
• for aluminium plate: 0.045 \( L_w^{0.5} k^{1/2} + 3 \)
  without being taken less than 4 mm or 3 mm for extruded panel,
where:
\[
L_w = 0.5 \left( L_{W1} + L_{W2} \right)
\]
b) Bottom plating
As a rule, the thicknesses of bottom plating are not to be lesser than the thickness of side shell.
c) Additional specific minimum thicknesses in relation to the service notation or service feature assigned to the ship are defined in Ch 6, Sec 1.

### 2.2.2 General case

a) 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:
\[
t = 22.4 \nu \sigma \left( \frac{p}{\sigma_{locam}} \right)^{0.5}
\]
where:
\[
p = \begin{cases} 
\nu \text{ local sea pressures or internal pressures, in kN/m}^2, & \text{as defined in Ch 3, Sec 3 and Ch 3, Sec 4, or} \\
\nu \text{ bottom impact pressure for flat bottom forward area, in kN/m}^2, & \text{as defined in Ch 3, Sec 3, [3.2], or} \\
\nu \text{ bottom slamming pressure for planing hull, } p_{s}, \text{ in kN/m}^2, & \text{as defined in Ch 3, Sec 3, [3.3]} 
\end{cases}
\]
\[
\nu \sigma = \begin{cases} 
\nu \text{ for steel plating: } \nu = 0.67 \\
\nu \text{ for transversely framed steel plating: } \nu = 0.77 \\
\nu \text{ for steel transverse bulkhead: } \nu = 1.00 \\
\nu \text{ for aluminium plating, whatever the frame system: } \nu = 1.00 \\
\nu \text{ bottom impact pressure for flat bottom forward area and for bottom slamming pressure for planing hull: } \\
\nu \text{ for steel plating: } \nu = 0.77 \\
\nu \text{ for aluminium plating: } \nu = 0.85 
\end{cases}
\]
b) For steel plating, where the thickness \( t \) calculated according to item a) is greater than 20 mm, the rule thickness, in mm, may be taken equal to:
\[
t = 0.9 t + t_{c}
\]
where \( t_{c} \) is to be taken equal to the sum of the corrosion addition for each exposed side of the plating as defined in NR467 Steel Ships, Pt B, Ch 4, Sec 2 Tab 2.
c) The thickness of sidescuttles located on the side shell are to be examined according to Ch 5, Sec 1, [7.3], taking into account the value of \( P \) defined in the present requirement.

### 2.2.3 Plating 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 formulae:

- if \( s \leq 0.6 \) m
\[
t = 17.3 \left[ \frac{1}{\lambda} \frac{\nu}{\sigma_{locam}} \frac{p}{\sigma_{locam}} \right]^{0.5}
\]
- if \( s > 0.6 \) m
\[
t = 13.4 \left[ \frac{1.5 s^2 - 0.18 s}{\lambda} \frac{\nu}{\sigma_{locam}} \right]^{0.5}
\]
where:
\[
p = \begin{cases} 
\nu \text{ Pressure, in kN/m}^2, & \text{to be taken equal to:} \\
\nu \text{ Impact pressure on side shell and, for multihull, on platform bottom, in kN/m}^2, & \text{as defined in Ch 3, Sec 3, [3.1.2] and/or Ch 3, Sec 3, [3.1.3]} \\
\nu \text{ Pressure coefficient equal to:} \\
\nu \text{ for steel plating: } \nu = 0.77 \\
\nu \text{ for aluminium plating: } \nu = 0.85 
\end{cases}
\]
\[
\nu \lambda = \begin{cases} 
\nu \text{ Length, in m, equal to:} \\
\nu \text{ for steel plating: } \nu = 0.6 (1 + s) \leq \ell \\
\nu \text{ for aluminium plating: } \nu = 0.85 (1 + s) \leq \ell 
\end{cases}
\]
The thickness of sidescuttles located on the side shell and submitted to side shell impact are to be examined according to Ch 5, Sec 1, [7.3], taking into account the value of \( P_{s} \) defined in the present requirement where applicable (see Ch 3, Sec 3, [3.1]).

### 2.2.4 Plating subjected to wheeled loads

The thickness of plate panels subjected to wheeled loads is to be not less than the value obtained, in mm, from the following formula:

- Single wheel or group of wheels:
\[
t = 0.9 C_m \nu \lambda \sqrt{F_w n_k}
\]
where:
\[
k = \begin{cases} 
\nu \text{ Material factor, defined in Ch 1, Sec 2, [2]} \\
\nu \text{ for steel and in Ch 1, Sec 2, [3] for aluminium alloys} \\
\nu \text{ Number of wheels on the plate panel:} \\
\nu \text{ 1 in the case of single wheel} \\
\nu \text{ the number of wheels in a group of wheels in the case of double or triple wheels} \\
\nu \text{ Coefficient equal to:} \\
\nu \text{ for steel: } \nu = 1.00 \\
\nu \text{ for aluminium: } \nu = 1.55 
\end{cases}
\]
\[
C_m = \begin{cases} 
\nu \text{ Coefficient to be taken equal to:} \\
\nu \text{ for steel: } C_m = 2.15 - 0.05 \left( 10^{0.25} - 1.75 \alpha^{0.25} \right) \\
\nu \text{ for aluminium: } C_m = 2.15 - 0.05 \left( 10^{0.25} - 1.75 \alpha^{0.25} \right)
\end{cases}
\]
where \( \ell/s \) is to be taken not greater than 3

\[
\alpha = \frac{\Delta T}{\ell/s}
\]

\( \Delta T \): Tyre print area, in m\(^2\). In the case of double or triple wheels, \( \Delta T \) is the print area of the group of wheels.

When the tyre print area is not known, it may be taken equal to:

\[
\Delta T = 9,8 n W \frac{n Q A}{n W p r}
\]

where:

\( Q A \): Axle load, in t

\( n W \): Number of wheels for the axle considered

\( p r \): Tyre pressure, in kN/m\(^2\). When the tyre pressure is not indicated by the Designer, it may be taken as defined in Tab 1

\( n \): Number of wheels on the plate panel, taken equal to:

- 1 in the case of a single wheel
- the number of wheels in a group of wheels in case of double or triple wheels

\( F_W \): Wheeled force, in kN, as defined in Ch 3, Sec 4, [3.3].

b) Wheels spread along the panel length:

In the case where two to four wheels of the same properties (load and tyre print area) are spread along the plate panel length as shown on Fig 1, the thickness of deck plating is to be not less than the value obtained, in mm, from the following formulae:

\[
t = t_1 \beta_i
\]

where:

\( t_1 \): Thickness obtained, in mm, from item a) with \( n = 1 \), considering one wheel located on the plate panel

\( n \): Number of wheels on the plate panel, to be taken not less than 2

\( \beta_i \): Coefficients obtained from the following formula, by replacing \( i \) by 2, 3 or 4, respectively (see Fig 1):

- for \( \alpha_i < 2 \):
  
  \[
  \beta_i = 0,8 (1,2 - 2,02 \alpha_i + 1,17 \alpha_i ^2 - 0,23 \alpha_i ^3)
  \]

- for \( \alpha_i \geq 2 \):
  
  \[
  \beta_i = 0
  \]

\( \alpha_i \): \( \alpha_i = x_i/s \)

\( x_i \): Distance, in m, from the wheel considered to the reference wheel (see Fig 1)

c) Wheels spread along the panel breadth:

In the case where two wheels of the same properties (load and tyre print area) are spread along the plate panel breadth as shown in Fig 2, the thickness of deck plating is to be not less than the value obtained, in mm, from the following formula:

\[
t = t_2 \delta
\]

where:

\( t_2 \): Thickness obtained, in mm, from item a) with \( n = 2 \), considering one group of two wheels located on the plate panel

\( \delta \): Coefficient obtained from the following formula:

\[
\delta = (\delta_1 + \delta_2)/2
\]

\( \delta_1 = 1 - \left( \frac{W_w}{S - V} \right) \)

\( \delta_2 = 1 - \left( \frac{3w_w^2 + 6w_wv}{3s^2 - 4v^2} \right) \)

\( W_w \): Distance between the two wheels, as shown in Fig 2

\( v \): Individual wheel breadth, as shown in Fig 2.
Where this two-wheels arrangement is repeated several times over the panel length (2, 3 or 4 times), the required thickness $t$ is to be multiplied by:

$$\sqrt{1 + \sum_{i=2}^{n} \beta_i}$$

as calculated in item b), where $n$ is the number of two wheels groups.

d) Wheels larger than the plate panel:

In the particular case of wheels or group of wheels where $u > s$, the tyre print outside of the plate panel is to be disregarded. The load and the area to be considered are to be adjusted accordingly (see Fig 3).

**Table 1 : Tyre pressures $p_T$ for vehicles**

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Tyre pressure $p_T$, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pneumatic tyres</td>
</tr>
<tr>
<td>Private cars</td>
<td>250</td>
</tr>
<tr>
<td>Vans</td>
<td>600</td>
</tr>
<tr>
<td>Trucks and trailers</td>
<td>800</td>
</tr>
<tr>
<td>Handling machines</td>
<td>1100</td>
</tr>
</tbody>
</table>

2.3 Scantling for composite panel

2.3.1 The scantling of composite and plywood panels is to be checked according to:

- the local loads defined in [1.2.1]
- the safety factor criteria defined in Ch 2, Sec 3, [3] for composite and Ch 2, Sec 3, [4] for plywood, and
- the calculation methodology defined in NR546 Composite Ships.
SECTION 4 LOCAL SECONDARY STIFFENER SCANTLING

Symbols

s : Spacing, in m, of the secondary stiffener under consideration

ℓ : Span, in m, of the secondary stiffener under consideration

k : Material factor, defined in Ch 1, Sec 2

σ_locam : Local permissible bending stress, in N/mm², as defined in Ch 2, Sec 3, in relation to the type of load

τ_locam : Local permissible shear stress, in N/mm², as defined in Ch 2, Sec 3, in relation to the type of load

m : End stiffener condition coefficient, defined in [1.4]

λ : Corrosion coefficient to be taken equal to:

- steel structure: 1,1
- for stiffener located in a dry compartment: 1,1
- for stiffener located in a liquid compartment: 1,2
- aluminium structure: 1,05.

1 General

1.1 Local scantling

1.1.1 General

The local secondary stiffener scantling is to be carried out according to:

- for steel structure: the present Section
- for aluminium structure: the present Section and NR561 Aluminium Ships
- for composite structure: the present Section and NR546 Composite Ships.

1.1.2 The scantling of secondary stiffeners contributing to the overall longitudinal strength of the hull girder and to the overall transverse strength of platform of multihull are also to be checked as defined in Sec 2.

1.2 Local loads

1.2.1 Local load types

The local lateral pressures to be considered are:

- for side shell and, for multihull, platform bottom secondary stiffeners: sea pressures and side shell impacts
- for deck secondary stiffeners: external or internal loads, minimum loads, and when applicable, wheeled loads
- for all stiffeners, when applicable: internal pressures.

The secondary stiffeners and their attached platings subjected to compression local loads are also to be checked against buckling criteria as defined in Sec 2, [2.3]. In this case, the value of σ_s considered in Sec 2, [2.3] is to be taken equal to the stress induced in the stiffener and its associated plate by the local loads.

1.2.2 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 Ch 3, Sec 1, [4].

1.3 Section modulus calculation

1.3.1 General case and attached plating width

As a rule, the inertia, section modulus and shear section of secondary stiffeners are to be determined by direct calculation.

The width b_p, in m, of the attached plating to be taken into account for the inertia and section modulus calculations are to be taken equal to the spacing between stiffeners, or half the spacing between stiffeners when the plating extends on one side only.

1.3.2 Bulb section for steel stiffeners

As a rule, the inertia, section modulus and shear section of bulb section of steel stiffener may to be determined taking into account the following equivalent dimensions of an angle profile:

\[ h_w = h'_w \left( \frac{h_w}{9.2} \right)^2 + 2 \]
\[ t_w = t'_w \]
\[ b_i = \alpha \left[ 0.67 + \frac{h'_w}{6.7} - 2 \right] \]
\[ t_i = \frac{h'_w}{9.2} - 2 \]

where:

- \( h'_w, t'_w \) : Height and thickness of the bulb section, in mm, as shown in Fig 1
- \( \alpha \) : Coefficient equal to:
  \[ 1 + \left( \frac{120 - h'_w}{3000} \right)^2 \quad \text{for} \quad h'_w \leq 120 \]
  \[ 1.0 \quad \text{for} \quad h'_w > 120 \]
1.3.3 Bulb section for aluminium stiffeners

For aluminium secondary stiffeners, the equivalent dimensions of an angle bar are as defined in [1.3.2] are not applicable.

The dimensions of the bulb section are to be specified by the Shipyard.

1.3.4 Stiffeners in composite materials

The inertia, section modulus and shear section of secondary stiffeners in composite materials are to be determined as defined in the NR546 Composite Ships.

1.4 End stiffener conditions for section moduli calculation

1.4.1 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 assumptions on end stiffener conditions are taken into consideration in the scantling formulae, using a coefficient \( m \) equal, successively, to:

- for fixed end condition: \( m = 12 \)
  
  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 condition: \( m = 8 \)
  
  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.

1.5 Span of stiffener

1.5.1 The span \( \ell \) of the stiffeners considered in the scantling formulae is to be measured as shown in Fig 2 to Fig 4.

1.5.2 For open floors, when a direct beam calculation taking into account all the elements of the open floor is not carried out, the span \( \ell \) of the upper and lower secondary stiffeners connected by one or two strut(s) is to be taken equal to \( 0.7 \ell_2 \) instead of \( \ell_1 \) (see Fig 5).
2 Secondary stiffener scantling

2.1 General

2.1.1 Loading cases and permissible stresses
The scantling of secondary stiffener is obtained considering successively the different loads sustained by the stiffener defined in [1.2.1] (combined as defined in Ch 3, Sec 1, [3.1] if relevant) and the permissible stresses defined in Ch 2, Sec 3.

2.1.2 Weld section of secondary stiffener
Where no stiffener brackets are provided at the connection between the secondary stiffener and the primary supporting element, the resistant weld section \( A_w \), in cm\(^2\), is not to be less than twice the value of \( A_{sh} \) defined in [2.2].

2.2 Scantling for steel and aluminium secondary stiffener

2.2.1 General

a) 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: \( 0.2 L_w k + 4 \)
- 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 1, Sec 2.

b) Minimum web and flange thicknesses:
As a rule, the thicknesses of web and flange are not to be less than:

1) for steel stiffeners:
- Flat bar:
  \[ \frac{h_w}{t_w} \leq 20 \sqrt[k]{k} \]
- Other section:
  \[ \frac{h_w}{t_w} \leq 55 \sqrt[k]{k} \]
  \[ b/t_i \geq \frac{h_w t_w}{6} \]
  for symmetrical flange:
  \[ \frac{b_i}{t_i} \leq 33 \sqrt[k]{k} \]
  or, for dissymmetrical flange:
  \[ \frac{b_i}{t_i} \leq 16, 5 \sqrt[k]{k} \]

2) for aluminium alloy stiffeners:
- Flat bar:
  \[ \frac{h_w}{t_w} \leq 15 \sqrt[k]{k} \]
- Other section:
  \[ \frac{h_w}{t_w} \leq 33 \sqrt[k]{k} \]
  \[ b/t_i \geq \frac{h_w t_w}{6} \]
  for symmetrical flange:
  \[ \frac{b_i}{t_i} \leq 21 \sqrt[k]{k} \]
  or, for dissymmetrical flange:
  \[ \frac{b_i}{t_i} \leq 10, 5 \sqrt[k]{k} \]

where:
\( h_w, t_w : \) Height and thickness of web, in mm
\( b_i, t_i : \) Width and thickness of face plate, in mm

2.2.2 General case
As a rule, the section modulus \( Z \), in cm\(^3\), and the shear area \( A_{sh} \), in cm\(^2\), of the secondary stiffeners subjected to lateral local pressures are to be not less than the values obtained from the following formulae:

- for horizontal stiffeners (longitudinal or transverse):
  \[ Z = 1000 \lambda C_p \frac{p \sigma^2}{\mu \sigma_{secam}} \]
  \[ A_{sh} = 5 \lambda C_p \frac{p s_f}{\sigma_{secam}} \]
  where:
  \( p : \) Local sea pressures or internal pressures, in kN/m\(^2\), as defined in Ch 3, Sec 3 and Ch 3, Sec 4, or
  Bottom impact pressure for flat bottom forward area, in kN/m\(^2\), as defined in Ch 3, Sec 3, [3.2], or
  Bottom slamming pressure for planing hull, \( p_{sl} \), in kN/m\(^2\), as defined in Ch 3, Sec 3, [3.3]
  \( C_p : \) Reduction coefficient defined as follows:
  - for sea pressures and internal pressure cases:
    \[ C_p = 1 - \frac{s}{2 \ell} \]
  - for other loading types:
    \[ C_p = 1.00 \]
• for vertical transverse stiffeners:

\[
Z = 1000\lambda C_p \frac{P \delta_I^2}{m_\sigma \delta_{locam}}
\]

\[
A_{sh} = 10\lambda C_p \frac{P \delta_I^2}{m_\tau \delta_{locam}}
\]

where:

- \( p_1, p_2 \) : Equivalent pressure, in kN/m², as defined in Tab 1
- \( m_b, m_s \) : End stiffener condition coefficients defined in Tab 1
- \( C_t \) : Reduction coefficient defined as follows:
  - for sea pressures and internal pressure cases:
    \[ C_t = 1 - \frac{s}{2\delta} \]
  - for other loading types:
    \[ C_t = 1,00 \]

### Table 1 : Equivalent pressures

<table>
<thead>
<tr>
<th>End stiffener condition</th>
<th>( p_1 )</th>
<th>( m_b )</th>
<th>( p_2 )</th>
<th>( m_s )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both ends fixed</td>
<td>2 ( P_{\text{upper}} ) + 3 ( P_{\text{lower}} )</td>
<td>60</td>
<td>3 ( P_{\text{upper}} ) + 7 ( P_{\text{lower}} )</td>
<td>20</td>
</tr>
<tr>
<td>Lower end fixed, upper end supported</td>
<td>7 ( P_{\text{upper}} ) + 8 ( P_{\text{lower}} )</td>
<td>120</td>
<td>9 ( P_{\text{upper}} ) + 16 ( P_{\text{lower}} )</td>
<td>40</td>
</tr>
<tr>
<td>Both ends supported</td>
<td>( P_{\text{upper}} ) + 2 ( P_{\text{lower}} )</td>
<td>16</td>
<td>( P_{\text{upper}} ) + 2 ( P_{\text{lower}} )</td>
<td>6</td>
</tr>
</tbody>
</table>

**Note 1:**

\( P_{\text{lower}}, P_{\text{upper}} \) : Sea pressure or internal pressure as defined in Ch 3, Sec 3 or Ch 3, Sec 4, in kN/m², calculated at lower end of the stiffener and at upper end of the stiffener respectively.

### 2.2.3 Secondary stiffeners under side shell impacts

As a rule, the section modulus \( Z \), in cm³, and the shear area \( A_{sh} \), in cm², of the horizontal and vertical secondary stiffeners sustaining lateral side shell impacts are to be not less than the values obtained from the following formulae:

\[
Z = 1000\lambda C_p \frac{P \delta_I^2}{m_\sigma \delta_{locam}}
\]

\[
A_{sh} = 5\lambda C_p \frac{P \delta_I^2}{m_\tau \delta_{locam}}
\]

where:

- \( P \) : Pressure, in KN/m², to be taken equal to:
  \[ P = C_P P_{\text{amin}} \]
- \( C_P \) : Pressure coefficient equal to:
  \[ C_P = -0,98s^2 + 0,3s + 0,95 \geq 0,8 \]
- \( s \) : Spacing of the stiffeners, in m, not to be taken greater than 0,6 m for the calculation of \( Z \) and \( A_{sh} \)
- \( p_{\text{amin}} \) : Impact pressure on side shell and, for multihull, on platform bottom, in kN/m², as defined in Ch 3, Sec 3, [3.1.2] and/or Ch 3, Sec 3, [3.1.3]
- \( C_P, C_t \) : Reduction coefficients equal to:
  \[ C_t = 0,3 \frac{3 - 0,36}{\delta} \geq 0,8 \]
  \[ C_t = 0,6 / \delta \text{ without being taken greater than 1.} \]

### 2.2.4 Secondary stiffeners under wheeled loads

As a rule, the secondary stiffeners scantling under wheeled loads are checked by direct calculation. Single span and multi span stiffeners are considered.

The values of the bending stresses \( \sigma \) and shear stresses \( \tau \), in N/mm², calculated according to the following approaches are to be less than the permissible stresses defined in Ch 2, Sec 3.

a) Single span stiffeners

The maximum normal stress \( \sigma \) and shear stress \( \tau \) are to be obtained, in N/mm², from the following formulae:

\[
\sigma = \alpha_w K_w \frac{F_w}{6 Z_a} 10^1
\]

\[
\tau = \alpha_w K_T \frac{10 F_w}{A_{sha}}
\]

where:

- \( Z_a, A_{sha} \) : Actual section modulus, in cm³, and shear section, in cm², of the stiffener considered
- \( F_w \) : Wheeled force, in kN, as defined in Ch 3, Sec 4, [3.3]
- \( \alpha_w \) : Coefficient taking into account the number of wheels per axle considered as acting on the stiffener, defined in Tab 2
- \( K_w, K_T \) : Coefficients taking into account the number of axles considered as acting on the stiffener, defined in Tab 3.

b) Multi span stiffeners

The maximum normal stress \( \sigma \) and shear stress \( \tau \) are to be obtained by a direct calculation taking into account:

- the distribution of wheeled loads applying on the stiffener
- the number and position of intermediate supports (girders, bulkheads, etc.)
- the condition of fixity at the ends of the stiffener and at intermediate supports
- the geometrical characteristics of the stiffener on the intermediate spans.
Table 2 : Wheeled loads - Coefficient $\alpha_w$

<table>
<thead>
<tr>
<th>Configuration</th>
<th>$\alpha_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single wheel</td>
<td>1</td>
</tr>
<tr>
<td>Double wheels</td>
<td>$2\left(1-\frac{y}{s}\right)$</td>
</tr>
<tr>
<td>Triple wheels</td>
<td>$3-2\frac{y}{s}$</td>
</tr>
</tbody>
</table>

Note 1: $y$ : Distance, in m, from the external wheel of a group of wheels to the stiffener under consideration, to be taken equal to the distance from the external wheel to the centre of the group of wheels.

Table 3 : Wheeled loads - Coefficients $K_S$ and $K_T$

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Single axle</th>
<th>Double axles</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K_S$</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$K_T$ : $1 + \frac{2}{\ell^2} \frac{d^2}{\ell^2} + \frac{d^4}{\ell^4}$

Note 1: $d$ : Distance, in m, between the two axles
$\ell$ : Span, in m, of the secondary stiffener under consideration

2.2.5 Struts for open floors
As a general rule, the scantling of the struts is to be checked by direct calculation, taking into account the compression and/or the tensile force $Q$, in kN, calculated as follows:

- compression force:
  \[ Q_c = \frac{s\ell^2}{4}(P_{\text{Bottom}} + P_{\text{DBottom}}) \]
- tensile force:
  \[ Q_t = \frac{2s\ell^2P_{\text{Ballast}}}{4} \]

where:

$P_{\text{Bottom}}$ : Local loads (wave loads and/or dynamic loads), in kN/m², applied on the ship bottom, as defined in Ch 3, Sec 3
$P_{\text{DBottom}}$ : Local loads, in kN/m², applied on the ship double bottom, as defined in Ch 3, Sec 4
$P_{\text{Ballast}}$ : Ballast local loads at mid-height of the ship double bottom, in kN/m², as defined in Ch 3, Sec 4
$\ell_2$ : Span of the upper and lower secondary stiffeners, as defined in Fig 5.

When deemed necessary by the Society, the buckling check of struts may be examined on a case-by-case basis.

2.3 Scantling of secondary stiffeners in composite materials

2.3.1 The scantling of composite and plywood stiffeners are to be checked according to:
- the local loads defined in [2.1.1]
- the safety factor criteria defined in Ch 2, Sec 3, [3] for composite and Ch 2, Sec 3, [4] for plywood, and
- the calculation methodology defined in NR546 Composite Ships.
SECTION 5 LOCAL PRIMARY STIFFENER SCANTLING

Symbols

\( \sigma_{VM} \) : Von Mises equivalent stress, obtained from the following formula:
\[
\sigma_{VM} = \sqrt{\sigma^2 + 3\tau^2}
\]
\( \sigma \) : Normal stress in the direction of the beam axis, induced by local loads
\( \tau \) : Shear stress in the direction of the local loads applied to the beam
\( \lambda \) : Corrosion coefficient taken equal to:
- for steel structure: \( \lambda = 1,10 \)
- for aluminium structure: \( \lambda = 1,05 \)

d) The scantling of primary stiffeners and their attached platings subjected to compression local loads are also to be checked against buckling criteria as defined in Sec 2, [2.3]. In this case, the value of \( \sigma \) considered in Sec 2, [2.3] is to be taken equal to the stress induced in the stiffener and its associated plate by the local loads.

e) Checking criteria
The bending stresses, shear stresses and combined stresses calculated by the model are to be in accordance with the permissible values defined in Ch 2, Sec 3.

1 General

1.1 Local scantling

1.1.1 The local primary stiffener scantling is to be carried out according to:
- for steel structure: the present Section
- for aluminium structure:
  the present Section and NR561 Aluminium Ships
- for composite structure:
  the present Section and NR546 Composite Ships.

1.1.2 The scantling of primary stiffeners contributing to the overall longitudinal strength of the hull girder and to the overall transverse strength of platform of multihull are also to be checked as defined in Sec 2.

1.2 Structural beam models

1.2.1 Isolated beam model

a) The requirements for the scantling of primary stiffeners defined in the present Section apply for isolated beam calculation.

b) Local loads
The local lateral pressures to be considered are defined in [1.2.2], b).

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 Ch 3, Sec 1, [4].

1.2.2 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, with their attached platting (as defined in [1.4.1]), 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 internal pressures, minimum loads and, when applicable, wheeled loads
- for all primary stiffeners, when applicable: internal pressures.

When deemed necessary, it may be taken into account of the counteraction between the internal and external loads in the most severe conditions (see Ch 3, Sec 1, [3.1.1]).

Note 1: When a bottom slamming pressure analysis is carried out for planing hull, the impact pressure \( p_i \) defined in Ch 3, Sec 3, [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 defined in Ch 3, Sec 3, [2.2.1].
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 Ch 3, Sec 1, [4].

d) Checking criteria:
It is to be checked that the equivalent stresses $\sigma_{VM}$ deduced from the model are in compliance with Ch 2, Sec 3.

1.2.3 Curved beam model
The curvature of primary supporting members may be taken into account by direct analysis.

In case of two dimensional or three dimensional beam structural model, the curved primary supporting members may 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 knuckle equivalent springs is considered as minor from the point of view of the local bending moment and the shear force distribution when the angle between two successive beams is not more than 3°.

1.3 Finite element model

1.3.1 General
When the analysis of primary stiffener structure is carried out by a finite element model, the model is to be submitted to the Society for examination.

As a rule, one of the procedure defined in NR467 Steel Ships, Pt B, Ch 7, App 1 is to be adopted for the finite element model.

It is to be checked that the equivalent stresses $\sigma_{VM}$ deduced from the finite element model calculation are in accordance with the permissible stresses defined in Ch 2, Sec 3.

1.4 Beam section modulus calculation

1.4.1 Attached plating
As a rule, the inertia, section modulus and shear section of primary stiffeners are to be determined by direct calculation.

The width $b_{pp}$ in m, of the attached plating to take into account for the inertia and section modulus calculations are to be taken equal to the spacing between primary stiffeners (or half of the spacing between primary stiffeners when the plating extends on one side only), without being taken greater than $0.2 \ell$ (or $0.1 \ell$ when the plating extends on one side only), where $\ell$ is the length of the primary stiffener.

1.5 End stiffener conditions for calculation

1.5.1 Definition and calculation conditions
The assumptions on end stiffener conditions for the calculation of section moduli of primary stiffeners are defined in Sec 4, [1.4.1].

As a rule, the coefficient m is to be taken equal to 10 for an isolated beam calculation of primary stiffener.

2 Primary stiffener scantling analysed by isolated beam calculation under local loads

2.1 Scantling for steel and aluminium primary stiffeners under lateral loads

2.1.1 Scantling
The primary stiffener scantling is to be carried out as defined for the secondary stiffener scantling in Sec 4, excepted otherwise specified, considering successively the different loads sustained by the primary stiffener defined in [1.2.1], item b) and the relevant permissible stresses defined in Ch 2, Sec 3.

The following parameters are to be taken into account in the section modulus and shear area formulae:
- Reduction coefficient $C_1 = 1$
- Corrosion coefficient $\lambda$ as defined in the present Section

The minimum section modulus for secondary stiffeners defined in Sec 4, [2.2.1] is not applicable to primary stiffeners.

2.1.2 Additional check of primary stiffeners
In addition to [2.1.1], the primary stiffeners are also to be examined taking into account the following requirements:

a) Buckling of attached plating:
Depending on the compression stress level in the attached plating induced by the bending of primary stiffener under the local loading cases, 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 2, Sec 3.

b) Minimum web thickness:
As a rule, the thickness of the web, in mm, for steel and aluminium structure is to be not less than:
- general case: $t = 1,2(3,7 + 0,015L_w)$
  where: $L_w = 0,5 (L_{wL} + L_{wH})$
- floors and bottom longitudinal girders:
  As defined in Tab 1

Additional specific minimum thicknesses of webs in relation to the service notation or service feature assigned to the ship are defined in Ch 6, Sec 1.

2.2 Scantling for steel and aluminium primary stiffeners under wheeled loads

2.2.1 Wheeled loads
For primary supporting members subjected to wheeled loads, the section modulus and shear area may be calculated as defined for secondary stiffener in Sec 4, [2.2.2], considering the distribution of the wheeled loads as an uniform pressures $p$. 
### Table 1: Minimum web thickness for floors and bottom longitudinal girders

<table>
<thead>
<tr>
<th></th>
<th>From aft to 0.7Lwl</th>
<th>From 0.7Lwl to fore</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steel</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single bottom</td>
<td>(5,5+0,05Lwk(^{1/2}))n_2C_T</td>
<td>(4+0,05Lwk(^{1/2}))n_2C_T</td>
</tr>
<tr>
<td>Double bottom</td>
<td>(4+0,04Lwk(^{1/2}))n_2C_T</td>
<td></td>
</tr>
<tr>
<td><strong>Aluminium</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single and double bottom</td>
<td>1,1n_2 (L_w+10)(^{1/2})</td>
<td></td>
</tr>
</tbody>
</table>

where:
- \(n_2\) : Navigation coefficient to be taken equal to:
  - **unrestricted navigation**: 1
  - **summer zone**: 0.95
  - **tropical zone**: 0.9
  - **coastal area**: 0.9
  - **sheltered area**: 0.85
  - **sea going launch**: 0.65 + 0.008L_w
  - **launch**: 0.65

- \(L_w\) : \(L_w = 0.5 (L_{wl} + L_{HULL})\)
- \(K\) : Material factor \(k\), as defined in Ch 1, Sec 2
- \(C_T\) : Draught coefficient taken equal to:
  - \(C_T = 0.7 + (3T/L_w)\) for \(L_w \leq 25m\)
  - \(C_T = 0.85 + (2T/L_w)\) for \(25m < L_w \leq 40m\)
  - \(C_T = 1\) for \(40m < L_w\)

This uniform pressure is to be equivalent to the distribution of vertical wheeled concentrated forces when such forces are closely located and is to be determined in the most unfavourable case, i.e. where the maximum number of axles are located on the same primary supporting member, according to Fig 1 and to Fig 2.

The uniform pressure \(p\), in kN/m², is to be calculated as follows:

\[
p = \frac{p_{eq}}{g} \left(1 + \alpha^2 \eta \right)
\]

where:
- \(p_{eq}\) : pressure equivalent to the vertical wheel distribution, in kN/m² to be taken equal to:
  \[
p_{eq} = 10n_v Q_A x_s (3 - x_s + \frac{x_s}{s})\]
- \(n_v\) : Maximum number of vehicles possible located on the primary supporting member
- \(Q_A\) : Maximum axle load, in t, as defined in Ch 3, Sec 4, [3.3.1]
- \(X_1\) : Minimum distance, in m, between two consecutive axles (see Fig 2)
- \(X_2\) : Minimum distance, in m, between axles of two consecutive vehicles (see Fig 2)
- \(a_z\) : Vertical acceleration, in m/s², as defined in Ch 3, Sec 4, [2.2]
- \(g\) : Gravity acceleration taken equal to 9.81 m/s²
- \(\alpha\) : Coefficient taken equal to:
  - 0.5 in general
  - 1.0 for landing gears of trailers
- \(\eta\) : Acceleration coefficient to be taken equal to:
  - 1.0 for ship in displacement mode
  - 0.4 for ship in planing mode.

#### 2.3 Primary stiffeners in composite materials

2.3.1 The scantling of composite and plywood stiffeners are to be checked according to:
- the local loads defined in [1.2.1], b) or [1.2.2], b)
- the calculation methodology defined in NR546 Composite Ships

2.3.2 Two- or three-dimensional structural model

When a two- or three-dimensional structural model is provided, the primary structure check is to be carried out as defined in [1.2.2] and in NR546 Composite Ships.
2.4 Scantling of primary stiffeners in way of launching appliances used for survival craft or rescue boat

2.4.1 The scantlings of deck primary supporting structure are to be determined by direct calculations, taking into account loads exerted by launching appliances corresponding to the SWL of the launching appliance.

For steel and aluminium structure, the combined stress $\sigma_{vm}$ in N/mm$^2$, is not to exceed $R_y/2.2$.

For composite structure, the combined stress safety factor $SF_{CS}$ defined in Ch 2, Sec 3, [3.2.3] is to be multiplied by a factor taken equal to 2.

3 Specific requirements

3.1 General

3.1.1 Material

The specific requirements defined in the present article are applicable to primary stiffeners made in steel.

Primary stiffeners made in aluminium are to be in accordance with the NR561 Aluminium Ships.

Primary stiffeners made in composite are to be in accordance with the NR546 Composite Ships.

3.2 Cut-outs and large openings

3.2.1 Cut-outs in web

Cut-outs for the passage of secondary 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.

3.2.2 Location of cut-out in web

As a general rule, 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. As a rule, 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.

3.2.3 Large openings

In case of large openings as shown in Fig 3, 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:

- Members (1) and (2) are subjected to the following forces, moments and stresses:

$$F = \frac{M_A + M_B}{2d}$$

$$m_1 = \frac{M_A - M_B}{2} K_1$$

$$m_2 = \frac{M_A - M_B}{2} K_2$$

$$\sigma_{F1} = 10 \frac{F}{S_1}$$

$$\sigma_{F2} = 10 \frac{F}{S_2}$$

$$\sigma_{m1} = \frac{m_1}{W_1} 10^{-1}$$

$$\sigma_{m2} = \frac{m_2}{W_2} 10^{-1}$$

$$\tau_1 = 10 \frac{K_1 Q_T}{S_{w1}}$$

$$\tau_2 = 10 \frac{K_2 Q_T}{S_{w2}}$$

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)
- $\sigma_{F1}, \sigma_{F2}$: Axial stresses, in N/mm$^2$, in (1) and (2)
- $\sigma_{m1}, \sigma_{m2}$: Bending stresses, in N/mm$^2$, in (1) and (2)
- $Q_T$: Shear force, in kN, equal to $Q_A$ or $Q_B$, whichever is greater
- $\tau_1, \tau_2$: Shear stresses, in N/mm$^2$, in (1) and (2)
- $w_1, w_2$: Section moduli, in cm$^3$, of (1) and (2)
- $S_{w1}, S_{w2}$: Sectional areas, in cm$^2$, of webs in (1) and (2)
- $I_1, I_2$: Moments of inertia, in cm$^4$, 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 $\sigma_c$ calculated at the ends of members (1) and (2) is to be obtained from the following formula:

$$\sigma_c = \sqrt{\left(\sigma_{F1} + \sigma_{m1}\right)^2 + 3 \tau_1^2}$$
3.3 Web stiffening arrangement for primary supporting members

3.3.1 Minimum thicknesses

As a rule, the thicknesses of web and flange are not to be less than:
- web:
  \[ \frac{h}{t_w} \leq 100 \sqrt{\kappa} \]
- face plate:
  for symmetrical flange:
  \[ \frac{b}{t_i} \leq 33 \sqrt{\kappa} \]
  or, for dissymmetric flange:
  \[ \frac{b}{t_i} \leq 16.5 \sqrt{\kappa} \]

Webs of primary supporting members are generally to be stiffened where their 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, in mm, not more than 110 t.

3.3.2 The moment of inertia \( I \), in cm<sup>4</sup>, of stiffeners of web of primary supporting members is to be not less than the value obtained from the following formula:

\[ I = 11.4 s t_w (2.5 \ell^2 - 2 s^2) \frac{R_{yy}}{235} \]

where:
- \( \ell \) : Length, in m, of the web stiffener (see Fig 7)
- \( s \) : Spacing, in m, of web stiffeners (see Fig 7)
- \( t_w \) : Web thickness, in mm, of the primary supporting member
- \( R_{yy} \) : Minimum yield stress, in N/mm<sup>2</sup>, as defined in Ch 1, Sec 2, of the material of the web of primary supporting member.

3.3.3 As a general rule, tripping brackets (see Fig 8) welded to the face plate are generally to be fitted:
- every fourth spacing of secondary 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.
3.3.4 The arm length $d$ of tripping brackets is to be not less than the greater of the following values, in m:

\[
\begin{align*}
  d & = 0.38b \\
  d & = 0.85b \frac{\sqrt{b t}}{t}
\end{align*}
\]

where:

- $b$ : Height, in m, of tripping brackets, shown in Fig 8
- $s_t$ : Spacing, in m, of tripping brackets
- $t$ : Thickness, in mm, of tripping brackets.

3.3.5 Steel 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 cm², 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.
SECTION 6  

STIFFENER BRACKETS SCANTLING AND STIFFENER END CONNECTIONS

1  General arrangement of brackets

1.1  Materials

1.1.1  The requirements of the present Section are applicable to hull made totally or partly in steel.

For ship hulls built in aluminium alloys, the requirements to apply are defined in NR561 Aluminium Ships, Section 6.

For ship hulls built in composite materials, the requirements to apply are defined in NR546 Composite Ships.

1.2  General requirements

1.2.1  As a general rule, 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 of end brackets are to be of the same length, 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 16.5 $L_b$ are to be flanged or stiffened by a welded face plate, such that:

- the sectional area, in cm$^2$, of the flanged edge or the face plate is at least equal to $10 L_b$,
- 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.

Figure 1: Bracket at upper end of secondary stiffener on plane bulkhead

Figure 2: Bracket at lower end of secondary stiffener on plane bulkhead
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:

- \( \varphi \) : Coefficient equal to:
  - for unflanged brackets: \( \varphi = 48,0 \)
  - for flanged brackets: \( \varphi = 43,5 \)
- \( w \) : Required section modulus of the supported stiffener, in cm^3
- \( t \) : Bracket thickness, in mm.

Figure 3 : Other bracket arrangement at lower end of secondary stiffeners on plane bulkhead

2.1.2 When a bracket is provided to ensure the simultaneous continuity of two (or three) stiffeners of equivalent stiffness, the bracket scantling is to be determined by direct calculation, taking into account the balanced bending moment in the connection of the two (or three) stiffeners.

3 Bracket ensuring continuity of secondary stiffeners

3.1 General

3.1.1 Where secondary stiffeners are cut in way of primary supporting members, brackets 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.
4 Bracketless end stiffeners connections

4.1 Bracketless end connections

4.1.1 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 formulae:

$$t_b = \frac{S_{f1} \cdot \sigma_1}{0.4h_1R_{y1}}$$

$$t_b = \frac{S_{f2} \cdot \sigma_2}{0.4h_2R_{y2}}$$

$$t_b = \text{Min} \left( t_1 ; t_2 \right)$$

where:

$S_{f1}, S_{f2}$: Flange sections, in mm$^2$, of member 1 and member 2, respectively.

$\sigma_1, \sigma_2$: Actual normal stresses, in N/mm$^2$, in member 1 and member 2, respectively.

$R_{y1}$: Minimum yield stress, in N/mm$^2$, as defined in Ch 1, Sec 2, of the material of the web of primary supporting member.

4.1.2 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:

$$t_b = \frac{S_{f1} \cdot \sigma_1}{0.4h_1R_{y1}}$$

$R_{y1}$: As defined in [4.1.1].

When the flanges of member 2 and member 3 are not continuous, the thickness of the common part of the webs is to be defined as [4.1.1].

4.1.3 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 100 $t_b$, the common part of the webs is generally to be stiffened.

4.1.4 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.
SECTION 7  

PILLAR SCANTLING

Symbols

- $A$: Cross-sectional area, in cm², of the pillar
- $I$: Minimum moment 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
- $\lambda$: Span, in m, of the pillar
- $f$: Fixity coefficient, to be obtained from Tab 1
- $r$: Minimum radius of giration, in cm, equal to:
  $$r = \frac{I}{A}\frac{1}{A}$$
- $\sigma_{y}$: Minimum guaranteed yield stress, in N/mm²
- $\sigma_{CB}$: Global pillar buckling stress, in N/mm²
- $\sigma_{CL}$: Local pillar buckling stress, in N/mm².

1 General

1.1 Materials

1.1.1 The requirements of the present Section are applicable to pillars built of:

- steel: as defined in Article [2]
- aluminium: as defined in Article [3]
- composite materials: as defined in Article [4].

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 2, Sec 1, [5.4].

1.2.2 Calculation approach

The pillar buckling stresses $\sigma_{CB}$ and $\sigma_{CL}$, in N/mm², and the maximal allowable axial load $P_C$, in kN, are to be successively examined according to the two following methods:

- global column buckling, and
- local buckling.

1.2.3 Actual compression axial load

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 in the pillar is to be obtained, in kN, from the following formula:

$$F_A = A_0 P_e + P_i + \sum r_i Q_i$$

<table>
<thead>
<tr>
<th>Table 1: Coefficient f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditions of fixity</td>
</tr>
<tr>
<td>f</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>(1) End clamped condition may only be considered when the structure in way of pillar ends can not rotate under the effect of loadings.</td>
</tr>
</tbody>
</table>
where:

$A_0$ : Area, in $m^2$, of the portion of the deck or the platform supported by the pillar considered

$p_s$ : Pressure on deck, in $kN/m^2$, as defined in Ch 3, Sec 4

$p_L$ : Local load on deck, in $kN$, if any Ch 3, Sec 4

$r$ : 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
- $r = 0.9i > 0.478$ 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.

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 $\sigma_{CB}$ is to be obtained, in $N/mm^2$, from the following formulae:

$$\sigma_{CB} = \sigma_t$$

for $\sigma_t \leq \frac{R_{eH}}{2}$

$$\sigma_{CB} = R_{eH} \left(1 - \frac{R_{eH}}{4\sigma_t}\right)$$

for $\sigma_t > \frac{R_{eH}}{2}$

where:

$\sigma_t$ : Euler column buckling stress of the pillar, in $N/mm^2$, to be obtained by the following formula:

$$\sigma_t = \pi^2 \frac{E}{(A/f)^{10^{-4}}}$$

2.1.2 Local critical buckling stress

The local critical buckling stress of pillars $\sigma_{CL}$ is to be obtained, in $N/mm^2$, from the following formulae:

$$\sigma_{CL} = \sigma_{ti}$$

for $\sigma_{ti} \leq \frac{R_{eH}}{2}$

$$\sigma_{CL} = R_{eH} \left(1 - \frac{R_{eH}}{4\sigma_{ti}}\right)$$

for $\sigma_{ti} > \frac{R_{eH}}{2}$

where:

$\sigma_{ti}$ : Euler local buckling stress, in $N/mm^2$, to be taken equal to the values obtained from the following formulae:

- For circular tubular pillars:
  $$\sigma_{ti} = 12.5 \left(\frac{E}{206000}\right) \left(\frac{D}{t}\right) 10^4$$
  where:
  $t$ : Pillar thickness, in mm
  $D$ : Pillar outer diameter, in mm

- For rectangular tubular pillars:
  $$\sigma_{ti} = 78 \left(\frac{E}{206000}\right) \left(\frac{b}{t}\right) 10^4$$

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:

$$10F \left(1 + \frac{\Phi e}{w_p}\right) + \left(10^3 \frac{M_{max}}{w_p}\right) \leq 0.85R_{eH}$$

where:

$F$ : Actual compression load, in $kN$, acting on the pillar

$A$ : Cross-sectional area, in $cm^2$, of the pillar

$e$ : Eccentricity, in cm, of the compression load with respect to the centre of gravity of the cross-section

$$\Phi = \frac{1}{1 - 10F \frac{1}{\sigma_{tA}}}$$

$\sigma_t$ : Euler column buckling stress, in $N/mm^2$, defined in [2.1.1]

$w_p$ : Minimum section modulus, in $cm^3$, of the cross-section of the pillar

$M_{max}$ : Max ($M_1, M_2, M_3$)

$M_1$ : 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

2.1.3 Maximum allowable axial load

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

$$P_C = \frac{\sigma_{CB}}{1.35} \cdot A \cdot 10^{-4}$$

$$P_C = \sigma_{CL} \cdot A \cdot 10^{-4}$$
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 defined in \([2.1]\) or \([2.2]\), taking into account an associated plating of a width equal to 30 times the plating thickness.

3 Pillar in aluminium material

3.1 General

3.1.1 The global critical column buckling stress \(\sigma_{CB}\) and the local critical buckling stress \(\sigma_{CL}\), in N/mm\(^2\), 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 \(S_{FCB}\) and \(S_{FCL}\):

\[
S_{FCB} = 0.34 \frac{f_r}{r} + 1.15
\]

\(S_{FCL} = 1.0\)

4 Pillar in composite material

4.1 Scantling criteria

4.1.1 The compression and buckling check of pillars made of composite materials are to be carried out according to NR546 Composite ships, Section 9, taking into account the following Rules safety factors in relation to the scantling criteria:

- Maximum stress in each layer:
  \[SF = 1.2 CF_C \]
- Combined stress in each layer:
  \[SF_{CS} = 1.2 CCS CF\]
- Local buckling:
  \[SF_{Buck} = 1.35 CF\]
- Global buckling:
  \[SF_{gBuck} = 1.75 CF\]

where

\(CF, CF_C : \) Partial safety factors defined in Ch 2, Sec 3, \([3.2.2]\)
\(CCS : \) For unidirectional tape, bi-bias, three unidirectional fabric:
\(CCS = 1.7, \) or
For other type of layer:
\(CCS = 2.1\)
APPENDIX 1  CALCULATION OF THE CRITICAL BUCKLING STRESSES

Symbols

\[ E : \text{Young’s modulus, in } \text{N/mm}^2, \text{to be taken equal to:} \]
- for steels in general:
  \[ E = 2.06 \times 10^5 \text{ N/mm}^2 \]
- for stainless steels:
  \[ E = 1.95 \times 10^5 \text{ N/mm}^2 \]

\[ R_{\text{eff}} : \text{Minimum guaranteed yield stress, in } \text{N/mm}^2, \text{as defined in Ch 1, Sec 2.} \]

1 General

1.1 Application

1.1.1 General
The requirements of this Appendix apply for the calculation of the critical buckling stresses of platings and stiffeners. Other values of critical buckling stresses may be taken into account if justified to the Society.

1.1.2 Checking criteria and materials
The critical buckling stresses are to be calculated according to:
- for steel structure: the present Appendix
- for aluminium structure: NR561 Aluminium Ships
- for composite structure: NR546 Composite Ships.

The buckling check of the structure is to be carried out as defined in Sec 2, [2.3].

2 Plating

2.1 Calculation hypothesis

2.1.1 General

a) General
Plate panels are considered as being simply supported. For specific designs, other boundary conditions may be considered, at the Society’s discretion, provided that the necessary information is submitted for review.

b) Plate panels subjected to compression and bending stresses:
For plate panels subjected to compression and bending stresses along one side, with or without shear, as shown in Fig 1, side “b” is to be taken as the loaded side. In such case, the compression stress varies linearly from \( \sigma_1 \) to \( \sigma_2 = \psi \sigma_1 \) (\( \psi \leq 1 \)) along edge “b”.

c) Plate panels subjected to bi-axial compression:
For plate panels subjected to bi-axial compression along sides “a” and “b”, and to shear, as shown in Fig 2, side “a” is to be taken as the side in the direction of the primary supporting members.

d) Plate panels subjected to shear stress:
For plate panels subjected to shear stress, as shown in Fig 3, side “b” may be taken as either the longer or the shorter side of the panel.

Figure 1: Buckling of panel subjected to compression and bending
2.1.2 Critical buckling for panel submitted to compression/bending stress

a) Buckling under simple compression (see Fig 1)

The critical buckling stress in compression/bending condition is to be obtained, in N/mm², from the following formulae:

$$\sigma_c = \frac{\pi^2 E}{12(1-\nu^2)} \left(\frac{1}{t}\right)^2 K_1 \varepsilon$$

where:

- $\sigma_c$: Euler buckling stress, to be obtained, in N/mm², from the following formula:
  $$\sigma_c = \frac{\pi^2 E}{12(1-\nu^2)} \left(\frac{1}{t}\right)^2 K_1 \varepsilon$$

- $t$: Minimum thickness of the plate panel, in mm
- $a, b$: Lengths, in m, of the sides of the panel, as shown in Fig 1 and Fig 2
- $K_1$: Buckling factor defined in Tab 1

$$\sigma_c = \frac{\pi^2 E}{12(1-\nu^2)} \left(\frac{1}{t}\right)^2 K_1 \varepsilon$$

b) Buckling under double compression (see Fig 2)

The critical buckling stresses $\sigma_{ca}$ (compression on side a) is to be obtained, in N/mm², from the following formula:

$$\sigma_{ca} = \frac{2.25}{\beta} - \frac{1.25}{\beta^2} \cdot ReH$$

where:

- $\beta$: Slenderness of the panel, to be taken equal to:
  - $\beta = 10^{1.3} \cdot \frac{ReH}{t}$

The critical buckling stresses $\sigma_{cb}$ (compression on side b) is to be obtained, in N/mm², from the same formula as for $\sigma_{ca}$, replacing, in $\beta$, length a by length b.

2.1.3 Critical buckling for panel submitted to shear stress

The critical shear buckling stress is to be obtained, in N/mm², from the following formulae (see Fig 3):

$$\tau_c = \tau_t \quad \text{for} \quad \tau_t \leq \frac{R_{crit}}{2\sqrt{3}}$$

$$\tau_c = \frac{R_{crit}}{\sqrt{3}} \left(1 - \frac{R_{crit}}{4\sqrt{3} \tau_t}\right) \quad \text{for} \quad \tau_t > \frac{R_{crit}}{2\sqrt{3}}$$

where:

- $\tau_c$: Euler shear buckling stress, to be obtained, in N/mm², from the following formula:
  $$\tau_c = \frac{\pi^2 E}{12(1-\nu^2)} \left(\frac{1}{t}\right)^2 K_2 \varepsilon$$

- $K_2$: Buckling factor to be taken equal to:
  - $K_2 = 5.34 + 4 \frac{a^2}{\alpha^2}$ for $\alpha > 1$
  - $K_2 = 5.34 + 4$ for $\alpha \leq 1$

- $\nu$: Poisson’s coefficient
- $t$: Minimum thickness of the plate panel, in mm
- $a, b$: Lengths, in m, of the sides of the panel, as shown in Fig 3

$$\alpha = \frac{a}{b}$$
3 Stiffeners

3.1 Calculation hypothesis

3.1.1 The critical buckling stresses for stiffener are to be obtained, in N/mm², from the following formulae:

\[
\sigma_e = \sigma_{e1} \quad \text{for} \quad \sigma_{e} \leq \frac{R_{eff}}{2}
\]

\[
\sigma_e = R_{eff} \left( 1 - \frac{R_{eff}}{4\sigma_e} \right) \quad \text{for} \quad \sigma_e > \frac{R_{eff}}{2}
\]

where:

\( \sigma_e = \min(\sigma_{e1}, \sigma_{e2}, \sigma_{e3}) \)

\( \sigma_{e1} \): Euler column buckling stress, in N/mm², equal to:

\[
\sigma_{e1} = \frac{\pi^2 E}{(\frac{I}{A})^2} \times 10^{-4}
\]

where:

\( I \): 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

\( \sigma_{e2} \): Euler torsional buckling stress, in N/mm², equal to:

\[
\sigma_{e2} = \frac{\pi^2 E I_p}{10^4 t y^3 (K^t + m^2)} + 0.385 \frac{L}{L_p} \times 10^{-4}
\]

where:

\( L \): Sectorial moment of inertia, in cm⁶, of the stiffener about its connection to the attached plating:

- for flat bars:
  \( L_p = \frac{bftf}{36} \times 10^6 \)
- for T-sections:
  \( L_p = \frac{tbh^2}{12} \times 10^6 \)
- for angles and bulb sections:
  \( L_p = \frac{bth^2}{12(b+h)^2}(t+2b+h^2+4h^2) + 3tbh \times 10^6 \)

\( I_p \): Polar moment of inertia, in cm⁸, of the stiffener about its connection to the attached plating:

- for flat bars:
  \( I_p = \frac{h^2t^4}{12} \times 10^6 \)
- for stiffeners with face plate:
  \( I_p = \frac{(h^2t^4 + 3bht)}{3} \times 10^4 \)

\( I_t \): St. Venant’s moment of inertia, in cm⁶, of the stiffener without attached plating:

- for flat bars:
  \( I_t = \frac{bth^2}{3} \times 10^4 \)
- for stiffeners with face plate:
  \( I_t = \frac{1}{3}(h_n t_n^4 + b_n t'_n(1 - 0.63 \frac{b}{h_n})) \times 10^4 \)
m : Number of half waves, to be taken equal to the integer number such that (see also Tab 2):
\[ m^2 (m - 1)^2 \leq K_c < m^2 (m + 1)^2 \]

\[ K_c = \frac{C_0 \pi^4}{E I w} 10^4 \]

\[ C_0 : \text{Spring stiffness of the attached plating:} \]
\[ C_0 = \frac{E I w}{2.735} 10^{-3} \]

\[ \sigma_{E3} : \text{Euler web buckling stress, in N/mm}^2, \text{equal to:} \]
- for flat bars:
\[ \sigma_{E3} = 16 \left( \frac{b w}{h_w} \right)^2 10^4 \]
- for stiffeners with face plate:
\[ \sigma_{E3} = 78 \left( \frac{b w}{h_w} \right)^2 10^4 \]

Table 2 : Torsional buckling of axially loaded stiffeners

<table>
<thead>
<tr>
<th>Number m of half waves</th>
<th>0 ≤ K_c &lt; 4</th>
<th>4 ≤ K_c &lt; 36</th>
<th>36 ≤ K_c &lt; 144</th>
</tr>
</thead>
</table>
APPENDIX 2
HULL SCANTLING CHECK WITH LOCAL AND GLOBAL STRESSES COMBINATION CRITERIA

Symbols

\( R_y \) : Minimum yield stress of the material, in N/mm\(^2\), used for the scantling criteria as defined in Ch 1, Sec 2.

\( P \) : Local pressures and forces defined in:
- for external pressure: Ch 3, Sec 3, [2]
- for internal pressures: Ch 3, Sec 4, [3] and Ch 3, Sec 4, [4]

\( \sigma_A \) : Actual overall stress, in N/mm\(^2\), calculated according to Sec 2 for hull girder loads defined in Ch 3, Sec 2, excluding the additional specific wave hull girder loads defined in Ch 3, Sec 2, [6].

In this Appendix, \( \sigma_A \) is to be taken greater or equal to 0.35 \( R_y \).

\( \mu \) : Aspect ratio coefficient of the elementary plate panel, equal to:
\[
\mu = 1.21 \left( 1 + 0.33 \left( \frac{s}{L} \right)^2 \right) - 0.69 \frac{s}{L}
\]
without being greater than 1.

\( m \) : End stiffener condition coefficient, defined in Sec 4, [1.4].

1 General

1.1 Application

1.1.1 The requirements of this Appendix apply for the check of hull structure elements contributing to the hull girder strength, built in steel or aluminium material, where overall stresses and local stresses are combined according to Ch 1, Sec 3, [2.1.2].

The structure elements not contributing to the hull girder strength are to be checked as defined in Sec 3, Sec 4 and Sec 5.

1.2 Overall stresses

1.2.1 The actual overall stresses are to be determined according to Sec 2 for hull girder loads defined in Ch 3, Sec 2, excluding the additional specific wave hull girder loads defined in Ch 3, Sec 2, [6].

As a rule, the values of the still water bending moments to take into account for the calculation of the actual overall stresses are to be given by the designer.

1.3 Local stresses

1.3.1 The local stresses to take into account in the present Appendix are those induced by the local pressures and forces defined in:
- for external pressure: Ch 3, Sec 3, [2]
- for internal pressures: Ch 3, Sec 4, [3] and Ch 3, Sec 4, [4]

2 Plating scantling

2.1 General

2.1.1 The plating thickness under local loads, in mm, is to be greater than the minimum value defined in Sec 3, [2.2.1] and the following value:

\[
t = 22, 4 \lambda m \sigma_{ad} \sqrt{\frac{P}{S}}
\]

where:
- \( s \) : Length, in m, of the shorter side of the plate panel
- \( n_p \) : Coefficient to be taken equal to:
  - Steel:
    - plate longitudinally framed: \( n_p = 0.67 \)
    - plate transversely framed: \( n_p = 0.77 \)
  - Aluminium:
    - Whatever the frame system: \( n_p = 1 \)
- \( \lambda \) : Corrosion coefficient to be taken equal to:
  - for steel plating: \( \lambda = 1.1 \)
  - for aluminium plating: \( \lambda = 1.05 \)
- \( \sigma_{ad} \) : Permissible stress, in N/mm\(^2\), as given in Tab 1.

### Table 1 : Permissible stress, in N/mm\(^2\)

<table>
<thead>
<tr>
<th>Material</th>
<th>Plate longitudinally framed</th>
<th>Plate transversely framed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel (1)</td>
<td>( \sigma_{ad} = 0.75 \lambda m R_y )</td>
<td>( \sigma_{ad} = 0.75 R_y - \sigma_A )</td>
</tr>
<tr>
<td>Aluminium</td>
<td>( \sigma_{ad} = \sqrt{55 R_y^2 - (1.1 \sigma_A^2)} )</td>
<td>( \sigma_{ad} = 0.75 R_y - \sigma_A )</td>
</tr>
</tbody>
</table>

(1) For plate longitudinally framed:

\[
\lambda_{LT} = \frac{1 - (\frac{\sigma_A}{R_y})^2}{(0, 25 \frac{\sigma_A}{R_y})}
\]

For plate transversely framed:

\[
\lambda_{LT} = 1 - \left( \frac{\sigma_A}{R_y} \right)
\]
3 Secondary stiffener scantling

3.1 General

3.1.1 The section modulus of secondary stiffener under local loads, in cm³, is to be greater than the minimum value defined in Sec 4, [2.2.1] and the following value:

\[
Z = \frac{1000\lambda C Ps \ell^2}{m \sigma_{ad}}
\]

where:
\(\lambda\) : Corrosion coefficient to be taken equal to:
- for steel structure: \(\lambda = 1,1\)
- for stiffener located in a dry compartment: \(\lambda = 1,2\)
- for aluminium structure: \(\lambda = 1,05\)

\(s\) : Spacing, in m, of the secondary stiffener under consideration

\(C_t\) : Reduction coefficient defined as follows:

\[
C_t = 1 - \frac{h}{2t}
\]

\(\ell\) : Span, in m, of the secondary stiffener under consideration

\(\sigma_{ad}\) : Permissible local scantling stress, in N/mm², to be taken equal to:
- for bottom and side girder:
  \(\sigma_{ad} = 0,80R_y - \sigma_A\)
- for other primary stiffeners:
  \(\sigma_{ad} = 0,85R_y - \sigma_A\)

The shear are \(A_{sh}\), in cm² is to be not less than the values defined in Sec 4, [2].

4 Primary stiffener scantling

4.1 Primary stiffener checked by isolated beam calculation

4.1.1 Section modulus

The section modulus of primary stiffener under local loads, in cm³, is to be greater than the following value:

\[
Z = \frac{1000\lambda Ps \ell^2}{m \sigma_{ad}}
\]

where:
\(\lambda\) : Corrosion coefficient to be taken equal to:
- for steel: \(\lambda = 1,2\)
- for aluminium: \(\lambda = 1,05\)

\(\sigma_{ad}\) : Permissible local scantling stress, in N/mm², to be taken equal to:
- for bottom and side girder:
  \(\sigma_{ad} = 0,80R_y - \sigma_A\)
- for other primary stiffeners:
  \(\sigma_{ad} = 0,85R_y - \sigma_A\)

The shear are \(A_{sh}\), in cm² is to be not less than the values defined in Sec 5, [2].

4.1.2 Buckling check of the associated plating

The associated plating of the primary stiffener is to be checked according to the following criterion:

\[
\sigma_c \geq SF (\sigma_A + \sigma_{loc})
\]

where:
\(\sigma_c\) : Critical buckling stress of the associated plating, in N/mm², calculated as defined in Sec 1, [2]
\(\sigma_{loc}\) : Actual local stress in the associated plating, in N/mm²

\(SF\) : Safety factor to be taken equal to:
- for steel structure: \(1,45\)
- for aluminium structure: \(1,30\).

4.2 Primary stiffener checked by three dimensional structural model

4.2.1 Checking criteria

For primary structure analysed under local loads by three dimensional structural model, it is to be checked that the equivalent Von Mises stress \(\sigma_{VM}\), in N/mm², is to comply with the following criterion:

\[
\sigma_{VM} \leq R_y / SF
\]

where:
\(\sigma_{VM}\) : Actual local bending and shear stresses, in N/mm²

\(SF\) : Safety factor to be taken equal to 1,25.

4.2.2 Buckling check of the associated plating

The associated plating of the primary stiffener is to be checked according to [4.1.2].
Chapter 5

OTHER STRUCTURES

SECTION 1  SUPERSTRUCTURES AND DECKHOUSES
SECTION 2  OTHER STRUCTURES
SECTION 3  HELICOPTER DECKS AND PLATFORMS
SECTION 4  ANCHORING EQUIPMENT AND SHIPBOARD FITTINGS FOR ANCHORING, MOORING AND TOWING EQUIPMENT
SECTION 1  SUPERSTRUCTURES AND DECKHOUSES

Symbols

- \( L_{WL} \) : Length at waterline at full load, in m
- \( L_{LL} \) : Load line length, in m
- \( B \) : Moulded breadth, in m
- \( T \) : Draught, at full load displacement, in m, measured from the base line (see Ch 3, Sec 3, Fig 1)
- \( s \) : Length, in m, of the shorter side of the plate panel
- \( \ell \) : Length, in m, of the longer side of the plate panel
- \( k \) : Material factor, defined in Ch 1, Sec 2, [2] for steel and in Ch 1, Sec 2, [3] for aluminium alloys
- \( \mu \) : Aspect ratio coefficient of the elementary plate panel, equal to:
  \[
  \mu = 1.21 \left( 1 + \frac{0.33}{\ell} \right) - 0.69 \frac{s}{\ell} \leq 1
  \]
- \( \sigma_{locam} \) : Local permissible bending stress, in N/mm\(^2\), as defined in Ch 2, Sec 3
- \( z \) : Distance, in m, between the base line and the calculation point (see Ch 3, Sec 3, Fig 1)
- \( \tau_{locam} \) : Local permissible shear stress, in N/mm\(^2\), as defined in Ch 2, Sec 3
- \( m \) : End stiffener condition coefficient, as defined in Ch 4, Sec 4, [1.4]
- \( n \) : Coefficient navigation defined in Ch 1, Sec 1, Tab 2.

1 General

1.1 Application

1.1.1 The requirements of this Section apply for the scantling of plating and associated structures of front, side and aft bulkheads and decks of superstructures and deckhouses.

1.1.2 Superstructures contributing to the hull longitudinal strength are to be examined taking into account the hull analysis approach defined in Ch 1, Sec 3, [2].

1.1.3 Materials

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.

1.2 Definitions

1.2.1 Superstructure

A superstructure is a decked structure connected to the freeboard deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating than 0,04 \( B \).

1.2.2 Deckhouse

A deckhouse is a decked structure other than a superstructure, located on the freeboard deck or above.

1.2.3 Superstructures and deckhouses contributing to the longitudinal strength

A superstructures and/or deckhouses extending over 0,4 \( L \) may generally be considered as contributing to the hull longitudinal girder strength.

In this case, a global strength analysis as defined in Ch 4, Sec 2 is to be carried out for the structure elements contributing to the hull longitudinal girder strength.

1.2.4 Tiers of superstructures and deckhouses

The lowest tier is normally that which is directly situated above the freeboard deck.

The second tier is that located immediately above the lowest tier, and so on.

1.2.5 Standard height of superstructure

The standard height of superstructure is defined in Tab 1.

<table>
<thead>
<tr>
<th>Load line length ( L_{LL} ), in m</th>
<th>Standard height ( h_S ), in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>( L_{LL} \leq 30 )</td>
<td>0,90</td>
</tr>
<tr>
<td>( 30 &lt; L_{LL} &lt; 65 )</td>
<td>( 0,9 + 0,00667 \left( L_{LL} - 30 \right) )</td>
</tr>
<tr>
<td></td>
<td>1,80</td>
</tr>
</tbody>
</table>

1.2.6 Position 1 and position 2

a) Position 1 includes:
   - exposed freeboard and raised quarter decks
   - exposed superstructure decks situated forward of 0,25 \( L_{LL} \) from the perpendicular, at the forward side of the stem, to the waterline at 85% of the least moulded depth measured from the top of the keel.

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b) Position 2 includes:

- exposed superstructure decks situated aft of 0,25 L from the perpendicular, at the forward side of the stem, to the waterline at 85% of the least moulded depth measured from the top of the keel and located at least one standard height of superstructure above the freeboard deck
- exposed superstructure decks situated forward of 0,25 LLL from the perpendicular, at the forward side of the stem, to the waterline at 85% of the least moulded depth measured from the top of the keel and located at least two standard heights of superstructure above the freeboard deck.

1.3 Superstructures and deckhouses structure arrangement

1.3.1 General
The general superstructures and deckhouses structure arrangements are to be as defined in Ch 2, Sec 1, [7].

2 Design loads

2.1 Load point

2.1.1 Lateral pressure is to be calculated at:
- the mid-height of the elementary plate panel, for plating
- mid-span, for stiffeners.

2.2 Lateral pressure on superstructure and deckhouse walls

2.2.1 General
The lateral pressure of the exposed walls of superstructure and deckhouses, in kN/m², is to be determined as follows:

\[ p = 10a \cdot c \cdot n \cdot b \cdot f \cdot z \cdot T \]

where:

- \( a \): Coefficient defined in Tab 2
- \( b \): Coefficient defined in Tab 3
- \( c \): Coefficient equal to:
  - for monohull: \( c = 0,30 + 0,70 \frac{b_1}{B_{ed}} \)
  - for multihull: \( c = 0,50 \)
- \( b_1 \): Breadth of the superstructure or deckhouse, in m, at the position considered, to be taken not less than 0,25 \( B_{ed} \)
- \( B_{ed} \): Actual maximum breadth of ship on the exposed weather deck, in m, at the position considered
- \( f \): Coefficient equal to:
  \( f = 0,076 \frac{L \text{WL}}{LWL} - 0,6 \)
- \( p_{min} \): Minimum lateral pressure, in kN/m², defined in [2.2.2].

b) Lowest tier of sidewalls of superstructure located in the plane of side shell:
The lateral pressure of the exposed lowest tier of sidewalls of superstructure, where the side wall is in the plane of side shell, is to be taken equal to the greater value obtained from the following formulae:

\[ P_s = \rho g (T + h_1 - z) \]

\[ P_s = \rho g \left( T + \frac{0,8 b_1}{2} \sin \alpha - z \right) \]

where:

- \( \rho \), \( g \), \( h_1 \), \( B_1 \) and \( A_e \): As defined in Ch 3, Sec 3, [2.2.1].
In addition, the side shell impact is to be determined according to Ch 3, Sec 3, [3.1].

c) Front wall sloped aft:
When the front wall is sloped aft, the front wall pressures \( p \) and \( p_{min} \) may be reduced by the value of the cosine of the angle \( \alpha \), where \( \alpha \) is defined in Fig 1.
The value of the angle \( \alpha \) is not to be taken smaller than 60°.

![Figure 1: Angle of superstructure](image)

Table 2: Coefficient a

<table>
<thead>
<tr>
<th>Location</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unprotected front wall</td>
<td></td>
</tr>
<tr>
<td>First tier</td>
<td>2 + \frac{L \text{WL}}{120}</td>
</tr>
<tr>
<td>Second tier</td>
<td>1 + \frac{L \text{WL}}{120}</td>
</tr>
<tr>
<td>Upper tiers</td>
<td>0,5 + \frac{L \text{WL}}{120}</td>
</tr>
<tr>
<td>Protected front wall</td>
<td></td>
</tr>
<tr>
<td>All tiers</td>
<td>0,5 + \frac{L \text{WL}}{150}</td>
</tr>
<tr>
<td>Aft wall</td>
<td></td>
</tr>
<tr>
<td>All tiers</td>
<td>0,5 + \frac{L \text{WL}}{1000}</td>
</tr>
<tr>
<td>Side walls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0,5 + \frac{L \text{WL}}{150}</td>
</tr>
</tbody>
</table>

Table 3: Coefficient b

<table>
<thead>
<tr>
<th>( \frac{x}{L \text{WL}} )</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{x}{L \text{WL}} \leq 0,25 )</td>
<td>1,10</td>
</tr>
<tr>
<td>0,25 &lt; ( \frac{x}{L \text{WL}} ) &lt; 0,70</td>
<td>1,00</td>
</tr>
<tr>
<td>0,70 \leq ( \frac{x}{L \text{WL}} ) &lt; 0,85</td>
<td>1,30</td>
</tr>
<tr>
<td>0,85 \leq ( \frac{x}{L \text{WL}} )</td>
<td>1,50</td>
</tr>
</tbody>
</table>
### Table 4 : Minimum lateral pressure for superstructures and deckhouses

<table>
<thead>
<tr>
<th>Type of wall</th>
<th>Location</th>
<th>$p_{\text{min}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unprotected front wall</td>
<td>lower tier</td>
<td>$x/LWL \geq 0.70$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$x/LWL &lt; 0.70$</td>
</tr>
<tr>
<td></td>
<td>upper tiers</td>
<td></td>
</tr>
<tr>
<td>Protected front wall</td>
<td>lower tier</td>
<td></td>
</tr>
<tr>
<td></td>
<td>second tier</td>
<td>$x/LWL &lt; 0.70$</td>
</tr>
<tr>
<td></td>
<td>upper tiers</td>
<td></td>
</tr>
<tr>
<td>Side walls</td>
<td>lower tier</td>
<td>$x/LWL \geq 0.70$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$x/LWL &lt; 0.70$</td>
</tr>
<tr>
<td></td>
<td>second tier</td>
<td></td>
</tr>
<tr>
<td></td>
<td>upper tiers</td>
<td></td>
</tr>
<tr>
<td>Unprotected aft wall</td>
<td>lower tier</td>
<td>$x/LWL \leq 0.25$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$x/LWL &gt; 0.25$</td>
</tr>
<tr>
<td></td>
<td>upper tier</td>
<td></td>
</tr>
<tr>
<td>Protected aft wall</td>
<td>anywhere</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:**
- $n$ : Navigation coefficient defined in Ch 1, Sec 1, [3.1.1] or Ch 1, Sec 1, [3.2.1]
- $\varphi_2$ : Coefficient taken equal to:
  $$\varphi_2 = \frac{LWL}{120} \geq 0.42$$

### 2.2.2 Minimum lateral pressure

The values of the minimum lateral pressures $p_{\text{min}}$, in KN/m², are defined in Tab 4.

Apart from the lower tier of unprotected front wall of superstructure, $p_{\text{min}}$ may be taken equal to 2.5 kN/m² when:

$$z > T + 0.5 B_1 A_K + h_1$$

where:
- $z$ : Z co-ordinate, in m, of the calculation point as defined in Ch 3, Sec 1, [4.1.1]
- $T$ : Moulded draught, in m, as defined in Ch 1, Sec 1, [4.5]
- $h_1$ : Ship relative motion, in m, in the considered longitudinal part of the ship as defined in Ch 3, Sec 3, [2.2.1]
- $B_1$ : Maximum moulded breadth, in m, in the considered longitudinal part of the ship as defined in Ch 3, Sec 3, [2.2.1]
- $A_K$ : Roll amplitude, in rad, as defined in Ch 3, Sec 4, [2.1.7].

### 2.3 Pressures on superstructure decks

#### 2.3.1 Exposed deck

The pressure on exposed decks, in kN/m², is defined in Ch 3, Sec 3, [2.2.2].

#### 2.3.2 Accommodation decks

The pressure on accommodation decks, in kN/m², is defined in Ch 3, Sec 4, [4.2].

### 3 Plating

#### 3.1 General

#### 3.1.1 Application

The present Article is applicable for the scantling of plating of front, side and aft bulkheads and decks of superstructures and deckhouses.

#### 3.2 Plating scantling

##### 3.2.1 As a rule, the thickness of plating, in mm, is to be not less than the following value:

$$t = 22, 4 \lambda n_p \mu \frac{p}{\sigma_{locam}} \geq t_{\text{min}}$$

where:
- $p$ : Lateral pressure, in kN/m² as defined in [2.2.1]
- $n_p$ : Coefficient to be taken equal to:
  - for longitudinally framed steel plating: $n_p = 0.67$
  - for transversely framed steel plating: $n_p = 0.77$
  - for aluminium plating, whatever the frame system: $n_p = 1.00$
- $\lambda$ : Corrosion coefficient taken, in the present Section, equal to:
  - for steel plate: $\lambda = 1.05$
  - for aluminium plate: $\lambda = 1.00$
- $t_{\text{min}}$ : Minimum thickness as defined in [3.2.2].

For the lowest tier of side walls of superstructure, where the side wall is in the plane of the side shell, the thickness of side wall plating is also to be not less than the value given in Ch 4, Sec 3, [2.2.3].

##### 3.2.2 Minimum thickness

As a rule, the minimum thickness $t_{\text{min}}$, in mm, is to be taken equal to:

- for steel structures: $t_{\text{min}} = 2.6 + 0.045 LWL \sqrt{k_1}$
- for aluminium structures: $t_{\text{min}} = 1.35 LWL^{1/3} \sqrt{k_1}$

without being less than 3.5 mm for rolled products and 2.5 mm for extruded products.

##### 3.2.3 Deck plating protected by wood sheathing

The thickness of deck plating protected by wood sheathing deemed suitable by the Society may be reduced on a case by case basis. In any case this thickness is to be not less than the minimum value defined in [3.2.2].

The sheathing is to be secured to the deck to the satisfaction of the Society.

##### 3.2.4 Scantling for composite panel

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

- local loads defined in [2]
- safety factor criteria defined in Ch 2, Sec 3, [3] for composite and Ch 2, Sec 3, [4] for plywood, and
- calculation methodology defined in NR546 Composite Ships.
4 Ordinary stiffeners

4.1 General

4.1.1 Application
The present Article is applicable for the scantling of ordinary stiffeners of front, side and aft bulkheads and decks of superstructures and deckhouses.

4.1.2 End stiffener condition for calculation
The connection of secondary stiffeners with surrounding supporting structure is taken into account in the rule section modulus, using coefficient m as defined in Ch 4, Sec 4, [1.4].

4.2 Ordinary stiffener scantling

4.2.1 Scantling for steel and aluminium ordinary stiffeners
As a rule, the section modulus Z, in cm³, and the shear area Ash, in cm², of the secondary stiffeners sustaining lateral local loads are to be not less than the values obtained from the following formulae:

\[ Z = \frac{1000 \lambda p \ell}{m \sigma_{locam}} > Z_{min} \]

\[ A_{sh} = 5 \lambda C t \frac{p \ell}{\sigma_{locam}} \]

where:

- \( C_t \): Reduction coefficient, equal to:
  - \( C_t = 1 - \frac{s}{2 \ell} \)
- \( p \): Lateral pressure, in kN/m², as defined in [2.2.1]
- \( \lambda \): Corrosion coefficient taken, in the present Section, equal to:
  - for steel stiffener: 1,05
  - for aluminium stiffener: 1,0
- \( Z_{min} \): Minimum section modulus as defined in [4.2.2].

For the lowest tier of side walls of superstructure, where the side wall is in the plane of the side shell, the section modulus of side wall ordinary stiffeners is to be also not less than the value given in Ch 4, Sec 4, [2.2.3].

4.2.2 Minimum section modulus
As a rule, the minimum section modulus \( Z_{min} \), in cm³, of secondary stiffeners calculated according to the present Section is to be taken equal to:

- for steel stiffener: \( Z_{min} = 3.5 + 0.15 LWL \times k \)
- for aluminium stiffeners: \( Z_{min} = 1.7 LWL^{1/3} \times k \)

4.2.3 Scantling for composite ordinary stiffeners
The scantling of composite and plywood ordinary stiffeners are to be checked according to:

- local loads defined in Article [2]
- safety factor criteria defined in Ch 2, Sec 3, [3] for composite and Ch 2, Sec 3, [4] for plywood, and
- calculation methodology defined in NR546 Composite Ships.

5 Primary stiffeners

5.1 General

5.1.1 The requirements for the scantling of primary stiffeners are to be as defined in Article [4] for ordinary stiffeners for isolated beam calculation.

For the lowest tier of side walls of superstructure, where the side wall is in the plane of the side shell, the check of primary stiffeners under side shell impact need not be carried out.

As a rule, the boundary condition to take into account for an isolated beam calculation is to correspond to \( m = 10 \).

When deemed necessary to the Society, it may be requested to carry out a two or three dimensional beam analysis calculations as defined in Ch 4, Sec 5, [1.2].

6 Arrangement of superstructures and deckhouses openings

6.1 General

6.1.1 The scope of application of the present Article is defined in Tab 5.

6.2 External openings

6.2.1 All external openings leading to compartments assumed intact in the damage analysis (which are below the final damage waterline) are required to be watertight and of sufficient strength.

6.2.2 No openings, be they permanent openings, recessed promenades or temporary openings such as shell doors, windows or ports, are allowed on the side shell between the embarkation station of the marine evacuation system and the waterline in the lightest seagoing condition.

Windows and sidescuttles of the non-opening type are allowed if they have a fire integrity at least equal to A-0 class.

Table 5: Scope of application

<table>
<thead>
<tr>
<th>Gross tonnage</th>
<th>≤ 500 (1)</th>
<th>&gt; 500 (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidescuttles, windows and skylights</td>
<td>NR566</td>
<td>[7]</td>
</tr>
<tr>
<td>Door arrangements</td>
<td>NR566</td>
<td>NR467</td>
</tr>
<tr>
<td>Freing ports</td>
<td>NR566</td>
<td>NR467</td>
</tr>
<tr>
<td>Machinery space openings</td>
<td>NR566</td>
<td>NR467</td>
</tr>
<tr>
<td>Companionway</td>
<td>NR566</td>
<td>NR467</td>
</tr>
<tr>
<td>Ventilation openings</td>
<td>NR566</td>
<td>NR467</td>
</tr>
<tr>
<td>Discharges</td>
<td>NR566</td>
<td>NR467</td>
</tr>
</tbody>
</table>

(1) Except ships having the following service notations:
- passenger ship with unrestricted navigation
- ro-ro passenger ship with unrestricted navigation
- fishing vessel, or
- chemical tanker

(2) And ships having the service notations defined in (1), whatever their tonnage.
6.2.3 Other closing appliances which are kept permanently closed at sea to ensure the watertight integrity of external openings are to be provided with a notice affixed to each appliance to the effect that it is to be kept closed. Manholes fitted with closely bolted covers need not be so marked.

7 Sidescuttles, windows and skylights

7.1 General

7.1.1 Application
The requirements in [7.2] to [7.4] apply to sidescuttles and rectangular windows providing light and air, located in positions which are exposed to the action of sea and/or bad weather.

7.1.2 Sidescuttle definition
Sidescuttles are round or oval openings with an area not exceeding 0,16 m².

7.1.3 Window definition
Windows are rectangular openings generally, having a radius at each corner relative to the window size in accordance with recognised national or international standards, and round or oval openings with an area exceeding 0,16 m².

7.1.4 Materials and scantlings
As a rule, sidescuttles and windows together with their glasses, deadlight and storm covers, if fitted, are to be of approval design and substantial construction in accordance with, or equivalent to, recognised national or international standards.

7.2 Opening arrangement

7.2.1 General
Sidescuttles are not to be fitted in such a position that their sills are below a line drawn parallel to the freeboard deck at side and having its lowest point 0,025 B or 0,5 m, whichever is the greater distance, above the summer load waterline (or timber summer load waterline if assigned).

7.2.2 Sidescuttles below (1,4 + 0,025 B) m above the water
Where in ‘tweendecks the sills of any of the sidescuttles are below a line drawn parallel to the bulkhead deck at side and having its lowest point (1,4 + 0,025 B) m above the water when the ship departs from any port, all the sidescuttles in that ‘tweendecks are to be closed watertight and locked before the ship leaves port, and they may not be opened before the ship arrives at the next port. In the application of this requirement, the appropriate allowance for fresh water may be made when applicable.

For any ship that has one or more sidescuttles so placed that the above requirements apply when it is floating at its deepest subdivision load line, the Society may indicate the limiting mean draught at which these sidescuttles are to have their sills above the line drawn parallel to the bulkhead deck at side, and having its lowest point (1,4 + 0,025 B) m above the waterline corresponding to the limiting mean draught, and at which it is therefore permissible to depart from port without previously closing and locking them and to open them at sea under the responsibility of the Master during the voyage to the next port. In tropical zones as defined in the International Convention on Load Lines in force, this limiting draught may be increased by 0,3 m.

7.2.3 Cargo spaces
No sidescuttles may be fitted in any spaces which are appropriated exclusively for the carriage of cargo.

Sidescuttles may, however, be fitted in spaces appropriated alternatively for the carriage of cargo or passengers, but they are to be of such construction as to prevent effectively any person opening them or their deadlights without the consent of the Master.

7.2.4 Non-opening type sidescuttles
Sidescuttles are to be of the non-opening type in the following cases:
- 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
- where they are fitted outside the space considered flooded and are below the final waterline for those ships where the freeboard is reduced on account of subdivision characteristics.

7.2.5 Opening of side scuttle
All sidescuttles, the sills of which are below the bulkhead deck for passenger ships or the freeboard deck for cargo ships, are to be of such construction as to prevent effectively any person opening them without the consent of the Master of the ship.

7.2.6 Manholes and flush scuttles
Manholes and flush scuttles in positions 1 or 2, or within superstructures other than enclosed superstructures, are to be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers are to be permanently attached.

7.2.7 Ships with several decks
In ships having several decks above the bulkhead deck, such as passenger ships, the arrangement of sidescuttles and rectangular windows is considered by the Society on a case-by-case basis. Particular consideration is to be given to the ship side up to the upper deck and the front bulkhead of the superstructure.

7.2.8 Automatic ventilating scuttles
Automatic ventilating sidescuttles are not to be fitted in the shell plating below the bulkhead deck of passenger ships and the freeboard deck of cargo ships without the special agreement of the Society.

7.2.9 Window arrangement
Windows may not be fitted below the freeboard deck, in first tier end bulkheads or sides of enclosed superstructures and in first tier deckhouses considered as being buoyant in the stability calculations or protecting openings leading below.
7.2.10 Skylights
Fixed or opening skylights are to have glass thickness appropriate to their size and position as required for sidescuttles and windows. Skylight glasses in any position are to be protected from mechanical damage and, where fitted in position 1 or 2, to be provided with permanently attached robust deadlights or storm covers.

7.2.11 Gangway, cargo and fuelling ports
Gangway, cargo and fuelling ports fitted below the bulkhead deck of passenger ships and the freeboard deck of cargo ships are to be watertight and in no case they are to be so fitted as to have their lowest point below the summer load line.

7.3 Windows and sidescuttles glasses

7.3.1 General
In general, toughened glasses with frames of special type are to be used in compliance with, or equivalent to, recognised national or international standards.

The use of clear plate glasses is considered by the Society on a case-by-case basis.

7.3.2 Scantling
The windows and sidescuttles scantling assessment methodology defined in this sub-article is equivalent to Standard ISO 21005:2004.

The edge condition of window and sidescuttle are considered as simple supported in the scantling formula.

7.3.3 Material
Attention is drawn to the use of plastic materials (PMMA, PC...) 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.

7.3.4 Thickness of monolithic glasses
a) General case:
The thicknesses, in mm, of monolithic glasses are to be obtained from the following formulae:
- rectangular glass:
  \[ t = 27.4s \left( \frac{pSf}{R_m} \right) \]
- circular glass:
  \[ t = 17.4d \left( \frac{pSf}{R_m} \right) \]
where:
- \( s \) : Shorter side, in m, of rectangular window or sidescuttle
- \( \ell \) : Longer side, in m, of rectangular window or side scuttle
- \( d \) : Diameter, in m, of circular window or sidescuttle
- \( p \) : Lateral pressure, in kN/m² as defined in [2.2.1]
- \( R_m \) : Guaranteed minimum flexural strength, in N/mm², of material used specified by the manufacturer.

When this value is not available, \( R_m \) may be taken, at a preliminary design stage, equal to:
- for glass thermally tempering (toughened):
  \[ R_m = 150 \text{ N/mm}^2 \]
- for glass chemically toughened:
  \[ R_m = 200 \text{ N/mm}^2 \]
- for polymethylacrylate (PMMA):
  \[ R_m = 100 \text{ N/mm}^2 \]
- for polycarbonate:
  \[ R_m = 80 \text{ N/mm}^2 \]

Other value of \( R_m \) may be taken into account on the basis of mechanical test results.

\( S_t \) : Safety factor taken equal to:
- for glass material: \( S_t = 5.0 \)
- for plastic material: \( S_t = 4.5 \)

\( \beta \) : Aspect ratio coefficient of the rectangular window or sidescuttle, obtained from Tab 6.

b) Windows and side scuttles submitted to side shell impact:
Where applicable according to Ch 3, Sec 3, [3.1] and when window or sidescuttle is located in the lowest tier of side walls of superstructure, where the side wall is in the plane of the side shell, the thickness, in mm, of monolithic glass is not to be less than the greatest value obtain from a) and from the following values:
- If \( s \leq 0.6 \text{ m} \) or \( d \leq 0.6 \text{ m} \):
  as defined in a) with:
  \[ p = \frac{C_p P_{ss\text{min}}}{S_t R_m} \]
  \( P_{ss\text{min}} \) : Impact pressure on side shell, in kN/m², as defined in Ch 3, Sec 3, [3.1.2] and/or Ch 3, Sec 3, [3.1.3]

\( S_t \) : Safety factor taken equal to:
- for glass material: \( S_t = 4.5 \)
- for plastic material: \( S_t = 4.0 \)

\( C_p \) : Pressure coefficient equal to:
\[ C_p = -0.98s^2 + 0.3s + 0.95 \geq 0.8 \]

- if \( s > 0.6 \text{ m} \) or \( d > 0.6 \text{ m} \):
  rectangular glass:
  \[ \frac{t_1 + \sqrt{2s - \beta S_t R_m}}{4} \]
  circular glass:
  \[ \frac{t_2 + \sqrt{2d - \beta S_t R_m}}{4} \]

with:
- \( p \) : Pressure, in kN/m², to be taken equal to:
  \[ p = \frac{C_p P_{ss\text{min}}}{S_t R_m} \]

\( C_p \) : Pressure coefficient equal to:
\[ C_p = -0.98s^2 + 0.3s + 0.95 \geq 0.8 \]

- for glass material: \( S_t = 4.5 \)
- for plastic material: \( S_t = 4.0 \)
Pressure coefficient equal to:

\[ C_p = -0.98s^2 + 0.3s + 0.95 \geq 0.8 \]

Safety factor taken equal to:

- for glass material: \( S_f = 4.5 \)
- for plastic material: \( S_f = 4.0 \)

### Table 6: Coefficient \( \beta \)

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</tr>
<tr>
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<td>0.750</td>
</tr>
</tbody>
</table>

### 7.3.5 Thickness of laminated glasses

Laminated glass are glass realized by placing a layer of resin (polyvinyl butyral as a general rule) between two sheets of glass.

The thickness of laminated glasses is to be calculated as defined in [7.3.4], considering the total thickness of the laminated glass as a monolithic glass.

### 7.3.6 Thickness of double glasses

Double glasses are glasses realized by two sheets of glass, separated by a spacebar hermetically sealed.

The thickness of the outside glass exposed to loads is to be calculated as defined in [7.3.4].

### 7.3.7 Thickness of glasses forming screen bulkheads or internal boundaries of deckhouses

The thickness of glasses forming screen bulkheads on the side of enclosed promenade spaces and that for rectangular windows in the internal boundaries of deckhouses which are protected by such screen bulkheads are considered by the Society on a case-by-case basis.

The Society may require both limitations on the size of rectangular windows and the use of glasses of increased thickness in way of front bulkheads which are particularly exposed to heavy sea.

### 7.4 Deadlight arrangement glasses

#### 7.4.1 General

Sidescuttles to the following spaces are to be fitted with efficient hinged inside deadlights:

- spaces below the freeboard deck
- spaces within the first tier of enclosed superstructures
- first tier deckhouses on the freeboard deck protecting openings leading below or considered buoyant in stability calculations.

Deadlights are to be capable of being closed and secured watertight if fitted below the freeboard deck and weathertight if fitted above.

#### 7.4.2 Watertight deadlights

Efficient hinged inside deadlights, so arranged that they can be easily and effectively closed and secured watertight, are to be fitted to all sidescuttles except that, abaft one eighth of the ship’s length from the forward perpendicular and above a line drawn parallel to the bulkhead deck at side and having its lowest point at a height of \( (3.7 + 0.025 B) \) m above the deepest subdivision summer load line, the deadlights may be portable in passenger accommodation other than that for steerage passengers, unless the deadlights are required by the International Convention on Load Lines in force to be permanently attached in their proper positions. Such portable deadlights are to be stowed adjacent to the sidescuttles they serve.

#### 7.4.3 Openings at the side shell in the second tier

Sidescuttles and windows at the side shell in the second tier, protecting direct access below or considered buoyant in the stability calculations, are to be provided with efficient, hinged inside deadlights capable of being effectively closed and secured weathertight.

#### 7.4.4 Openings set inboard in the second tier

Sidescuttles and windows set inboard from the side shell in the second tier, protecting direct access below to spaces listed in [7.4.1], are to be provided with either efficient, hinged inside deadlights or, where they are accessible, permanently attached external storm covers of approved design and substantial construction capable of being effectively closed and secured weathertight.

Cabin bulkheads and doors in the second tier separating sidescuttles and windows from a direct access leading below may be accepted in place of fitted deadlights or storm covers.

Note 1: Deadlights in accordance with recognised standards are fitted to the inside of windows and sidescuttles, while storm covers of comparable specifications to deadlights are fitted to the outside of windows, where accessible, and may be hinged or portable.

#### 7.4.5 Deckhouses on superstructures of less than standard height

Deckhouses situated on a raised quarterdeck or on a superstructure of less than standard height may be treated as being on the second tier as far as the provision of deadlights is concerned, provided the height of the raised quarterdeck or superstructure is not less than the standard quarterdeck height.

#### 7.4.6 Openings protected by a deckhouse

Where an opening in a superstructure deck or in the top of a deckhouse on the freeboard deck which gives access to a space below the freeboard deck or to a space within an enclosed superstructure is protected by a deckhouse, then it is considered that only those sidescuttles fitted in spaces which give direct access to an open stairway need to be fitted with deadlights.
SECTION 2  OTHER STRUCTURES

Symbols

- \( L_{WL} \) : Length at waterline at full load, in m
- \( T \) : Draught, at full load displacement, in m, as defined in Ch 1, Sec 1, [4.5]
- \( k \) : Material factor defined in Ch 1, Sec 2, [2.1.5] for steel, and in Ch 1, Sec 2, [3.1.3] for aluminium.

1  Fore part structure

1.1  General

1.1.1  Application

The requirements of this Article apply for the scantling and the structure arrangement of structures located forward of the collision bulkhead for steel and aluminium structure.

Fore part of composite hull structure is to be examined according to NR546 Composite Ships.

1.1.2  Scantlings

The scantlings of the fore part structure and the flat bottom area are to be checked as defined in Chapter 4.

Adequate tapering is to be ensured between the structure in the fore part and the structure aft of the collision bulkhead.

Fore peak structures which form the boundary of spaces not intended to carry liquids, and which do not belong to the outer shell, are to be subjected to lateral pressure in flooding conditions. Their scantlings are to be determined as defined in Chapter 4.

As a rule, secondary and primary stiffeners on side shell are to be calculated according to Ch 4, Sec 4, taking into account a connection with surrounding structure in simply supported end conditions (\( m = 8 \) in the section modulus formulae).

1.2  Stems

1.2.1  General

Adequate continuity of strength is to be ensured at the connection of stems and surrounding structure. Abrupt changes in sections are to be avoided.

1.2.2  Bar stems

The cross-sectional area, in \( \text{cm}^2 \), of bar stems built of forged, rolled or casting steel or aluminium is to be not less than:

- for steel structure:
  \[
  A_p = \left( 0.40 + 10 \frac{T}{L_{WL}} \right) (0.0125L^2 + 28)k^{0.5}
  \]
  with \( 0.05 < T/L_{WL} < 0.075 \)

- for aluminium structure:
  \[
  A_p = \left( 0.40 + 10 \frac{T}{L_{WL}} \right) (0.0125L^2 + 28)k^{0.5}
  \]
  with \( 0.05 < T/L_{WL} < 0.075 \)

The thickness of the bar stem, in mm, is to be not less than:

- for stem in steel:
  \[ t = (0.40 L_{WL} + 13)k^{0.5} \]
- for stem in aluminium:
  \[ t = (0.55 L_{WL} + 18)k^{0.5} \]

The cross-sectional area of the stem may be gradually tapered from the load waterline to the upper end, where it may be equal to the two thirds of the value as calculated above.

The lower part of the stem may be constructed of cast steel or aluminium alloy casting subject to the examination by the Society. Where necessary, a vertical web is to be fitted for welding of the centre keelson.

The bar stem is to be welded to the bar keel generally with butt welding.

The shell plating is also to be welded directly to the bar stem with butt welding.

1.2.3  Plate stems

Where the stem is constructed of shaped plates, the thickness of the plates below the load waterline is to be not less than the value obtained, in mm, from the following formulae:

- for steel structure:
  \[ t_s = 1.37(0.95 + \sqrt{L_{WL}})k^{0.5} \]
- for aluminium structure:
  \[ t_s = 1.90(0.95 + \sqrt{L_{WL}})k^{0.5} \]

Above the load waterline, this thickness may be gradually tapered towards the stem head, where it is to be not less than that required for side plating at ends.

As a rule, the expanded width of the stem, in m, is not to be less than:

\[ b = 0, 8 + 0, 5 \frac{L_{WL}}{100} \]

The plating forming the stems is to be supported by horizontal diaphragms spaced about 1000 mm apart and connected, as far as practicable, to the adjacent frames and side stringers.

If considered necessary, and particularly where the stem radius is large, a centreline stiffener or web of suitable scantlings is to be fitted.
1.3 Reinforcements of the flat bottom forward area

1.3.1 General
In addition to the requirements in [1.1], the structures of the flat bottom forward area are to be able to sustain the dynamic pressures due to the bottom impact where applicable as defined in Ch 3, Sec 3, [3.2.1].

1.3.2 Scantlings
The area defined in Ch 3, Sec 3, [3.2.2] is to be reinforced as defined below:

a) Plating and secondary stiffeners
The scantlings of plating and secondary stiffeners are to be not less than the values obtained in Ch 4, Sec 3, [2.2.2] and Ch 4, Sec 4, [2.2.2], taking into account the bottom impact pressure $p_{Bi}$ defined in Ch 3, Sec 3, [3.2.3].

b) Primary stiffener structure
As a rule, primary structure is to be checked through direct calculation considering a pressure of $0.3 \times p_{Bi}$, where $p_{Bi}$ is the bottom impact pressure defined in Ch 3, Sec 3, [3.2.3].

c) Tapering
Outside the flat bottom forward area, scantlings are to be gradually tapered so as to reach the values required for the areas considered.

1.4 Bow flare

1.4.1 General

a) Bow flare structure
The bow flare area is the area extending forward of $0.9 \times \text{LWL}$ from the aft end of LWL and above the summer load waterline up to the level at which a knuckle with an angle greater than $15^\circ$ is located on the side shell.
The bow flare structure is to be checked as defined in Chapter 4 taking into account the external pressure defined in Ch 3, Sec 3.
In addition, primary supporting members are generally to be checked through direct calculations.

When deemed necessary by the Society, the bow impact pressures to take into account for the structure check according to Chapter 4 may be taken equal to the values defined in NR467 Steel Ships, Pt B, Ch 8, Sec 1, [4].

Note 1: As a rule, this bow impact pressure may be taken into account for ship greater than 40 m having a value of angle $\beta$ greater than $25^\circ$, where $\beta$ is the angle between a longitudinal line parallel to the centerline of the ship and the tangent to the shell plating in a horizontal plane.

b) Bow flare arrangement
Outside the bow flare area, scantlings are to be gradually tapered so as to reach the values required for the areas considered.

Intercostal stiffeners are to be fitted at mid-span where the angle between the stiffener web and the attached plating is less than $70^\circ$.

1.5 Bulbous bow

1.5.1 General
The thickness of the shell plating of the fore end of the bulb and the first strake above the keel is generally to be not less than that required for the stems.
The structure arrangement of the bulbous bow is to be as defined in NR467 Steel Ships, Ch 8, Sec 1, [2.11].

1.6 Thruster tunnel

1.6.1 Scantling of the thruster tunnel and connection with the hull
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.

2 Aft part structure

2.1 General

2.1.1 Application
The requirements of this Article apply for the scantlings of structures located aft of the after peak bulkhead and for the reinforcements of the flat bottom aft area for steel and aluminium structure.

Aft part of composite hull structure are to be examined according to NR546 Composite Ships.

2.1.2 Scantling
The scantling of the aft part structure is to be checked as defined in Chapter 4.

Adequate tapering is to be ensured between the scantlings in the aft part and those fore of the after peak bulkhead. The tapering is to be such that the scantling requirements for both areas are fulfilled.

Aft peak structures which form the boundary of spaces not intended to carry liquids, and which do not belong to the outer shell, are to be subjected to lateral pressure in flooding conditions. Their scantlings are to be determined as defined in Chapter 4.

As a rule, the minimum thicknesses, in mm, of the following structure elements of ship built in steel materials or in aluminium alloys are to be not less than:

- for bottom and side plating:
  \[
  t = (0, 03L_{W} + 5, 5)k^{1/2}
  \]

- for inner bottom plating:
  \[
  t = 3 + 0, 017\text{L}_{W}k^{1/2} + 4, 5s
  \]

- for strength deck plating:
  \[
  t = 2, 3 + 0, 013\text{L}_{W}k^{1/2} + 4, 5s
  \]

- for platform and swash bulkhead:
  \[
  t = 2, 3 + 0, 004\text{L}_{W}k^{1/2} + 4, 5s
  \]
2.2 After peak

2.2.1 Arrangement
The arrangement of transversely framed after peak structure is to be as defined in NR467 Steel Ships, Pt B, Ch 8, Sec 2, [3].

2.3 Other structures

2.3.1 Connection of hull structures with the rudder horn
The connection of hull structure with the rudder horn is to be as defined in NR467 Steel Ships, Pt B, Ch 8, Sec 2, [5].

2.3.2 Sternframes
Sternframes scantling, arrangement and connection to the hull are to be as defined in NR467 Steel Ships, Pt B, Ch 8, Sec 2, [6].

3 Machinery spaces

3.1 Application

3.1.1 The requirements of this Article apply for:
- the arrangement of machinery space for ships built in steel, aluminium and composite materials
- the scantling of machinery space structures as regards general strength for ships built in steel and aluminium.

It is no substitute to machinery manufacturer’s requirements which have to be dealt with at Shipyard diligence.

The Designer may propose arrangements and scantlings alternative to the requirements of this Article, on the basis of direct calculations which are to be submitted to the Society for examination on a case-by-case basis.

The Society may also require such direct calculations to be carried out whenever deemed necessary.

3.2 General

3.2.1 Unless otherwise specified in this Article, the scantling of platings and stiffeners in the machinery space are to be determined according to the relevant criteria in Chapter 4, as applicable. In addition, specific requirements specified in this Section apply.

3.2.2 The structural continuity of the machinery space with hull structures located aft and forward is to be as defined in Ch 2, Sec 1.

3.2.3 Machinery space openings and access doors to casings are to be in accordance with:
- NR467 Steel Ships for ships of 500 GT and over and for all ships having the service notation passenger ship, ro-ro passenger ship, fishing vessel or chemical tanker
- NR566 for the other ships.

3.3 Double bottom

3.3.1 General
The general double bottom arrangement is to be as defined in Ch 2, Sec 1, [3].

Access arrangement is to be as defined in Ch 2, Sec 2, [5.2]. However, the number and size of manholes in floors located in way of seatings and adjacent areas are to be kept to the minimum necessary for double bottom access and maintenance.

3.3.2 Primary structure scantling
The scantling of double bottom primary structure, for steel and aluminium alloys, is to be as defined in Ch 4, Sec 5. In addition, the thickness \( t \), in mm, of floor and girder webs is to be not less than:

\[
t = 5 + 0.045 L^{1/2}
\]

3.3.3 Double bottom girders
In the machinery space the number of side bottom girders is to be adequately increased, with respect to the adjacent areas, to ensure adequate rigidity of the structure.

The side bottom girders are to be a continuation of any bottom longitudinal in the areas adjacent to the machinery space and are generally to have a spacing not greater than 3 times that of longitudinal and in no case greater than 3 m.

Additional side bottom girders are to be fitted in way of machinery seatings.

Side bottom girders arranged in way of main machinery seatings are to extend for the full length of the machinery space.

Where the machinery space is situated amidships, the bottom girders are to extend aft of the after bulkhead of such space for at least three frame spaces, and beyond to be connected to the hull structure by tapering.

Where the machinery space is situated aft, the bottom girders are to extend as far aft as practicable in relation to the shape of the bottom and to be supported by floors and side primary supporting members at the ends.

3.3.4 Double bottom floors
As a rule, floors are to be fitted in way of machinery.

3.4 Single bottom

3.4.1 General
The general single bottom arrangement is to be as defined in Ch 2, Sec 1, [3].

Furthermore, additional floors are to be fitted in way of important machinery.
As a rule, floors and girders are to be fitted with welded face plates in the engine room and especially in way of:

- engine bed plates
- thrust blocks
- auxiliary seatings.

### 3.4.2 Primary structure scantling

The scantling of single bottom primary structure, for steel and aluminium alloys, is to be as defined in Ch 4, Sec 5. In addition, the thickness \( t \), in mm, of floor and girder webs is to be not less than:

\[
t = 5 + 0.045 L k^{1/2}
\]

### 3.5 Side

#### 3.5.1 Arrangement

The type of side framing in machinery spaces is generally to be the same as adopted in the adjacent areas.

When it is not the case, the structural continuity of the machinery side with surrounding structures located aft and forward is to be as defined in Ch 2, Sec 1, and abrupt structural discontinuities between longitudinally and transversely framed structure are to be avoided.

### 3.6 Platforms

#### 3.6.1 The location and extension of platforms in machinery spaces are to be arranged so as to be a continuation of the structure of side longitudinals, as well as of platforms and side girders located in the adjacent hull areas.

In general, platform transverses are to be arranged in way of side or longitudinal bulkhead transverses.

### 3.7 Pillaring

#### 3.7.1 Pillars are generally to be arranged in way of:

- machinery casing corners and corners of large openings on platforms; alternatively, two pillars may be fitted on the centreline (one at each end of the opening)
- the intersection of platform transverses and girders
- transverse and longitudinal bulkheads of the superstructure.

In general, pillars are to be fitted with brackets at their ends.

#### 3.7.2 Pillar bulkhead scantlings are to be not less than those required in [3.8] for machinery casing bulkheads.

### 3.8 Machinery casing

#### 3.8.1 The scantlings of plating and stiffeners are to be not less than those obtained according to the applicable requirements in Chapter 4.

Casings are to be reinforced at the ends by deck beams and girder associated to pillars.

### 3.9 Seatings of main engines

#### 3.9.1 General

The scantling of seatings of main engines and thrust bearings are to be adequate in relation to the weight and power of engines and the static and dynamic forces transmitted by the propulsive installation.

Transverse and longitudinal members supporting the seatings are to be located in line with floors and bottom girders. They are to be so arranged as to avoid discontinuity and ensure sufficient accessibility for welding of joints and for surveys and maintenance.

Seatings are to be adequately connected to floors and girders with flanged brackets.

### 3.9.2 Scantling

The scantlings of the structural elements in way of the seatings of engines are to be determined by the engine manufacturer. They are to be checked on the basis of justificative calculations supplied by the engine manufacturer.

### 4 Side shell and bulkhead doors

#### 4.1 General

#### 4.1.1 Application

The requirements of this article apply to the scantling of shell doors and doors in bulkheads that are required to be watertight or weathertight.

#### 4.1.2 Door scantlings

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.

#### 4.1.3 Securing and supporting structure

Securing arrangement and supporting structure are to be as defined in NR467 Steel Ships, Pt B, Ch 8, Sec 12 [4], taking into account the permissible local stresses defined in Ch 2, Sec 3, Tab 4.

#### 4.1.4 Inspection and testing

The requirements of NR467 Steel Ships, Pt B, Ch 8, Sec 12 [5] are applicable.

#### 4.1.5 Type approval procedure

The requirements of NR467 Steel Ships, Pt B, Ch 8, Sec 12 [6] are applicable.

### 5 Bow doors and inner doors

#### 5.1 General

#### 5.1.1 Application

The requirements of this Article apply to the arrangement, strength and securing of bow doors and inner doors leading to a complete or long forward enclosed superstructure or to a long non-enclosed superstructure, where fitted to attain minimum bow height equivalence.

The requirements apply to ships engaged on international voyages and also to ships engaged only in domestic (non international) voyages, except where specifically indicated otherwise in this Article.
5.1.2 Type of bow doors

The type of bow door considered in the present article are:

- visor doors opened by rotating upwards and outwards about an horizontal axis through two or more hinges located near the top of the door and connected to the primary supporting members of the door by longitudinally arranged lifting arms
- side-opening doors opened either by rotating outwards about a vertical axis through two or more hinges located near the outboard edges or by horizontal translation by means of linking arms arranged with pivoted attachments to the door and the ship. It is anticipated that side-opening bow doors are arranged in pairs.

Other types of bow door are considered by the Society on a case by case basis in association with the applicable requirements of this Section.

5.2 Scantling and arrangement

5.2.1 The scantling of the plating and the secondary stiffeners of bow doors are to be checked as defined in Chapter 4 for the fore part of the hull.

5.2.2 Primary supporting members, securing and supporting devices

The primary supporting members, securing and supporting devices of bow doors and inner doors are to be checked according to the following design loads:

- For bow door: greater value between loads defined in Ch 3, Sec 3, [2.2.1] and in NR467 Steel Ships, Pt B, Ch 8, Sec 5 [2.1]
- For inner door: loads defined in NR467 Steel Ships, Pt B, Ch 8, Sec 5 [2.2]

Scantlings of primary supporting members are generally to be verified through direct calculations taking into account:

a) Steel structure:
Scantling criteria defined in NR467 Steel Ships, Pt B, Ch 8, Sec 5 [6].

b) Aluminium structure:
For structures built in aluminium alloys, it is to be checked that the normal stresses $\sigma$, the shear stress $\tau$ and the equivalent stress $\sigma_{VM}$, induced in the primary supporting members and in the securing and supporting devices of bow doors are in compliance with the following conditions:

$$\sigma \leq \sigma_{\text{ALL}}$$
$$\tau \leq \tau_{\text{ALL}}$$
$$\sigma_{VM} = (\sigma^2 + 3 \tau^2)^{0.5} \leq \sigma_{VM,\text{ALL}}$$

where:

- $\sigma_{\text{ALL}}$ : Allowable normal stress, in N/mm², equal to: $\sigma_{\text{ALL}} = 50 / k$
- $\tau_{\text{ALL}}$ : Allowable shear stress, in N/mm², equal to: $\tau_{\text{ALL}} = 35 / k$
- $\sigma_{VM,\text{ALL}}$ : Allowable equivalent stress, in N/mm², equal to: $\sigma_{VM,\text{ALL}} = 65 / k$

c) Composite structure:
For composite structure, it is to be checked that the scantling criteria defined in Ch 2, Sec 3, [3.2.1] are fulfilled, where the Rules safety factors SF and SF$_{CS}$ are to be increased by 60%.

5.3 Securing and locking arrangement

5.3.1 The securing and locking arrangement are to be as defined in NR467 Steel Ships, Pt B, Ch 8, Sec 5, [7].

5.4 Operating and Maintenance Manual

5.4.1 An Operating and Maintenance Manual for the bow door and inner door is to be provided on board and is to contain the necessary information defined in NR467 Steel Ships, Pt B, Ch 8, Sec 5, [8].

6 Side doors and stern doors for Ro-Ro ships

6.1 General

6.1.1 Application

The requirements of this Article apply to the arrangement, strength and securing of side doors located abaft the collision bulkhead, and of stern doors leading to enclosed spaces.

The requirements apply to ships assigned with the service notation ro-ro passenger ship or ro-ro cargo ship engaged on international voyages and also in domestic (non-international) voyages, except where specifically indicated otherwise in this article.

6.2 Scantling and arrangement

6.2.1 Arrangement

Side doors and stern door arrangements are to be as defined in NR467 Steel Ships, Pt B, Ch 8, Sec 6 [1.3].

6.2.2 The scantling of the plating and the secondary stiffeners of the side doors and stern doors are to be checked as defined in Chapter 4 for side hull.

Where doors also serve as vehicle ramps, the thickness of the door plating and the scantling of the secondary stiffeners are to be as defined in Chapter 4 under wheeled loads.

The primary supporting members are to be checked accordingly:

- NR467 Steel Ships, Pt B, Ch 8, Sec 6, [2.1.1] for design external forces
- NR467 Steel Ships, Pt B, Ch 8, Sec 6, [5] for strength criteria.

For aluminium alloy or composite structure, the primary supporting members are to be checked according criteria defined in [5.2.2] b) and c) respectively.
6.3 Securing, supporting of doors and locking arrangement

6.3.1 Securing, supporting of doors and locking arrangement are to be as defined in NR467 Steel Ships, Pt B, Ch 8, Sec 6, [4] and [6].

6.4 Operating and Maintenance Manual

6.4.1 An Operating and Maintenance Manual for the side doors and stern doors is to be provided on board and is to contain the necessary information defined in NR467 Steel Ships, Pt B, Ch 8, Sec 6, [7].

7 Hatch covers

7.1 Small hatch covers

7.1.1 Definition
Small hatches are hatches designed for access to spaces below the deck and are capable to be closed weathertight or watertight, as applicable. Their opening is generally less than or equal to 2.5 m².

7.1.2 Scantling
The scantling and stiffeners of hatch coamings and hatch covers are to be not less than that of the adjacent deck structure, calculated according to Chapter 4, based on the same spacing.

7.1.3 Arrangements
The arrangement of access, height of coamings, securing and closing devices is to be as defined in NR467 Steel Ships, Pt B, Ch 8, Sec 8.

7.2 Large hatch covers

7.2.1 Definition
Large hatches are hatches with openings greater than 2.5 m².

7.2.2 General
The requirements of the present sub-article apply for the scantling and the arrangement of large hatch covers and hatch coamings of stiffened plate construction and its closing arrangements built in steel.

The arrangement of hatch covers built in other materials are examined by the Society on a case-by-case basis.

7.2.3 Scantling and arrangement
Excepted where specified in [7.2.5], the scantling and the arrangement of hatch covers and hatch coamings are examined on a case-by-case basis, based on the requirements defined in NR467 Steel Ships, Pt B, Ch 8, Sec 7.

7.2.4 Buckling strength of hatch coamings
When the hatch coamings contribute to the longitudinal hull girder strength, the buckling strength assessment of coaming parts is to be carried out according to Ch 4, Sec 2.

7.2.5 The scantling and the arrangement of hatch covers and hatch coamings for ship having the service notation bulk carrier, ore carrier and combination carrier are to be as defined in NR467 Steel Ships, Pt D, Ch 4, Sec 4.

8 Movable decks, inner ramps and external ramps

8.1 Application

8.1.1 The requirements of this Article apply to movable decks and inner ramps when the additional class notation ALP is not granted and when no cargo gear register is issued.

8.1.2 On special request of the owner the movable inner ramps under load may be examined by the Society in the scope of the application of NR526 Rules for the Certification of Lifting Appliances on board Ships and Offshore Units and the assignment of additional class notation ALP (see NR467 Steel Ships, Pt A, Ch 1, Sec 2).

8.2 Scantling

8.2.1 Materials
The movable decks and inner ramps are to be made of steel or aluminium alloys complying with the requirements of NR216 Materials and Welding. Other materials of equivalent strength may be used, subject to a case-by-case examination by the Society.

8.2.2 Plating and secondary stiffener scantling
The thickness of plate panels and the section modulus and shear sectional area of secondary stiffeners subjected to wheeled loads are to be not less than the value obtained from Ch 4, Sec 3 and Ch 4, Sec 4, as applicable, with a value of \( F_w n \) (or \( F_w \) for secondary stiffeners) to be taken not less than 5 kN, where:

\[
F_w : \text{Wheeled force, in kN, as defined in Ch 3, Sec 4, [3.3]} \\
n : \text{Number of wheels on the plate panel as defined in Ch 4, Sec 3, [2.2.4].}
\]

8.3 Primary supporting members

8.3.1 General
The supporting structure of movable decks and inner ramps is to be examined through direct calculation, considering the following cases:

- movable deck stowed in upper position, empty and locked, at sea
- movable deck in service, loaded, in lower position, resting on supports or supporting legs and locked, at sea
- movable inner ramp in sloped position, supported by hinges at one end and by a deck at the other, with possible intermediate supports, loaded, at harbour
- movable inner ramp in horizontal position, loaded and locked, at sea.

8.3.2 Loading cases
The scantlings of the structure are to be checked in both sea and harbour conditions for the following cases:
• loaded movable deck or inner ramp under loads according to the load distribution indicated by the Designer

• loaded movable deck or inner ramp under uniformly distributed loads corresponding to a pressure, in kN/m², equal to $p_0 + p_1$

• empty movable deck under uniformly distributed masses corresponding to a pressure, in kN/m², equal to $p_0$

where:

$$p_0 = \frac{P_P}{A_P}$$

$$p_1 = n_V \frac{P_V}{A_P}$$

$P_P$ : Mass of the movable deck, in kN

$P_V$ : Mass of a vehicle, in kN

$n_V$ : Maximum number of vehicles loaded on the movable deck

$A_P$ : Effective area of the movable deck, in m².

### 8.3.3 Lateral pressure

The vertical and lateral pressures $p_i$ in kN/m² transmitted to the movable deck or inner ramp structures in $x$, $y$ and $z$ directions to take into account in harbour and sea conditions are to be obtained from Tab 1.

### 8.3.4 Checking criteria

It is to be checked that the combined stress $\sigma_{VM}$ is in accordance with the criteria defined in Ch 2, Sec 3. The scantlings of main stiffeners and the distribution of supports are to be such that the deflection of the loaded movable deck or loaded inner ramp does not exceed 5 mm/m.

### 8.4 Supports, suspensions and locking devices

### 8.4.1 Scantlings of wire suspensions are to be checked by direct calculation on the basis of the loads in [8.3.2] and [8.3.3], taking into account a safety factor at least equal to 5.

It is to be checked that the combined stress $\sigma_{VM}$ in rigid supports and locking devices is in accordance with the criteria defined in Ch 2, Sec 3.

### 8.5 Tests and trials

### 8.5.1 Tests and trials defined in [8.5.2] to [8.5.4] are to be carried out in the presence of the Surveyor. Upon special request, these conditions of tests and trials may be modified to comply with any relevant national regulations in use.

### 8.5.2 The wire ropes are to be submitted to a tensile test on test-piece.

### Table 1 : Movable decks and inner ramps lateral pressure

<table>
<thead>
<tr>
<th>Ship condition</th>
<th>Lateral pressure $p_i$ in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea</td>
<td>$P_x = \frac{(p_0 + p_1) \alpha_x}{g}$</td>
</tr>
<tr>
<td></td>
<td>$P_y = 0.7 \frac{(p_0 + p_1) \alpha_y}{g}$</td>
</tr>
<tr>
<td></td>
<td>$P_z = (p_0 + p_1) + (p_0 + p_1) \eta \alpha_z / g + 0.7 \gamma \alpha_x / g$</td>
</tr>
<tr>
<td>Harbour during lifting</td>
<td>$p_0 = 1.2 p_0$</td>
</tr>
<tr>
<td>at rest</td>
<td>$p_0 = 0.035 (p_0 + p_1)$</td>
</tr>
<tr>
<td></td>
<td>$p_0 = 0.087 (p_0 + p_1)$</td>
</tr>
<tr>
<td></td>
<td>$p_0 = 1.100 (p_0 + p_1)$</td>
</tr>
</tbody>
</table>

Note 1:

- $g$ : Gravity acceleration taken equal to 9.81 m/s²
- $\alpha_x$ : Longitudinal acceleration, in m/s², taken equal to: $\alpha_x = 0.65 \frac{z}{T} + 0.55$
- $\alpha_y$ : Transversal acceleration, in m/s², taken equal to: $\alpha_y = \alpha_x (z - T)$
- $\alpha_z$ : Vertical acceleration, in m/s², as defined in Ch 3, Sec 4, [2.2]
- $\alpha_R$ : Roll acceleration, in rad/s², as defined in Ch 3, Sec 4, [2.1.7]
- $\eta$ : Acceleration coefficient to be taken equal to:
  - 0.5 for ship in displacement mode
  - 0.4 for ship in planing mode
- $y$, $z$ : Transversal and vertical co-ordinates, in m, of the centre of gravity of the ramp
- $T$ : Minimum draught of the ship, in m.

### 8.5.3 The loose gears used for the platform and ramp handling (chain, shackles, removable blocks, etc.) are to have a maximum safe working load (SWL) and are to be submitted to an individual test before fitting on board.

The test of these loose gears are to be in accordance with the applicable requirements of NR526 Rules for the Certification of Lifting Appliances on board Ships and Offshore Units.

### 8.5.4 A trial to verify the correct operation of lowering and lifting devices of the platform is to be carried out before going into service.

This trial is made without overload unless special requirement of National Authorities.

### 8.6 External ramps

### 8.6.1 The external ramps are to be able to operate with a heel angle of 5° and a trim angle of 2°.

### 8.6.2 The thicknesses of plating and the scantlings of secondary stiffeners and primary supporting members are to be determined under vehicle loads in harbour condition, at rest, as defined in Tab 1.

### 8.6.3 The external ramps are to be examined for their watertightness, if applicable.
8.6.4 The locking of external ramps in stowage position at sea is examined by the Society on a case-by-case basis.

8.6.5 The ship structure under the reactions due to the ramp is examined by the Society on a case-by-case basis.

9 Rudders

9.1 General

9.1.1 The scantling of rudders built in steel is to be in accordance with the requirements defined in NR467 Steel Ships, Pt B, Ch 9, Sec 1.

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

$$k_1 = \frac{235}{R_y}$$

where:

$R_y$ : Minimum yield stress of aluminium, in N/mm$^2$, defined in Ch 1, Sec 2, [3.1.2].

For planing hull as defined in Ch 1, Sec 1, [2.1.4], the ahead service speed to take into account in the rudder check is to be taken equal to the minimum value between:

- $V_{AV}$
- $2/3 (V_{AV} + 2 LWL^{0.5})$

where:

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

Rudders built in composite materials are to be examined on a case-by-case basis by the Society taking into account safety factor criteria defined in Ch 2, Sec 3, [3.1] where Rules safety factors are to be increased by a coefficient to be taken at least equal to 1.3.

9.2 Rudder horn and solepiece

9.2.1 General

Arrangement of rudder horn and solepiece are to be in accordance with NR467 Steel Ships, Pt B, Ch 9, Sec 1.

9.2.2 Rudder horn scantling

The scantling of rudder horn built in steel is to be as defined in NR467 Steel Ships, Pt B, Ch 9, Sec 1, [8].

For rudder horn in aluminium alloys, the allowable stresses to be taken into account are the following ones:

- $\sigma_{B,ALL}$ : Allowable bending stress, in N/mm$^2$, equal to: $\sigma_{B,ALL} = 35 / k$
- $\tau_{ALL}$ : Allowable shear stress, in N/mm$^2$, equal to: $\tau_{ALL} = 20 / k$

For ships with notation launch or seagoing launch, the allowable stresses may be increased by 10%.

Solepiece in composite materials are to be examined on a case-by-case basis by the Society taking into account safety factor criteria defined in Ch 2, Sec 3, [3.1] where the Rules safety factors are to be increased by a coefficient to be taken at least equal to:

- for the main stress safety factor: 1.9
- for the combined stress safety factor: 1.3

9.2.3 Solepieces scantling

The scantling of solepieces built in steel is to be as defined in NR467 Steel Ships, Pt B, Ch 9, Sec 1, [8].

For solepieces in aluminium alloys, the allowable stresses to be taken into account are the following ones:

- $\sigma_{B,ALL}$ : Allowable bending stress, in N/mm$^2$, equal to: $\sigma_{B,ALL} = 35 / k$
- $\tau_{ALL}$ : Allowable shear stress, in N/mm$^2$, equal to: $\tau_{ALL} = 20 / k$

For ships with notation launch or seagoing launch, the allowable stresses may be increased by 10%.

Solepiece in composite materials are to be examined on a case-by-case basis by the Society taking into account safety factor criteria defined in Ch 2, Sec 3, [3.1] where the Rules safety factors are to be increased by a coefficient to be taken at least equal to:

- for the main stress safety factor: 1.9
- for the combined stress safety factor: 1.3

10 Water jet propulsion tunnel

10.1 General

10.1.1 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 hull structure and the calculation procedure from the Designer are to be specified.

10.1.2 Water jet supporting structure in steel or aluminium

The supporting structure of waterjets is to be able to withstand the loads induced by the waterjet in the following conditions:

- maximum ahead thrust
- maximum thrust at maximum lateral inclination
- maximum reversed thrust (going astern).

Information on the above loads is to be given by the waterjet manufacturer.

For each waterjet, the following loading cases are to be investigated:

- LDC1 : Internal hydrodynamic pressure $p_h$ in the built-in nozzle
- LDC2 : Horizontal longitudinal force $F_{xy}$ in normal service (ahead)
- LDC3 : Horizontal transverse force $F_y$ and associated moment $M_y$ during steering operation
LDC4 : Horizontal longitudinal force $F_x$, vertical force $F_z$ and overturning moment $M_y$ in crash-stop situation.

The actual location of the thrust bearing is to be adequately considered (either located aft of the stem in the stator bowl or inside the waterjet compartment).

The scantlings are to be checked by direct calculations.

Tab 2 indicates the loading cases to be considered for the various components of the waterjet system. Other loading cases could be considered for specific or new design.

The stress criteria for static analysis, in N/mm$^2$, may be taken as follows:

- bending stress: $\sigma_{locam} = 0.65 \, R$
- shear stress: $\tau_{locam} = 0.45 \, R$
- combined stress: $\sigma_{VMam} = 0.80 \, R$

(calculated according to Von Mises criteria)

where:

$R$ : Minimum yield stress value defined in Ch 2, Sec 3, [2.1.1].

The stress criteria for fatigue analysis are to be specified by the Designer.

The shell thickness in way of nozzles as well as the shell thickness of the tunnel are to be individually considered. In general, such thicknesses are to be not less than 1.5 times the thickness of the adjacent bottom plating.

General principles to be followed for such structures subject to cyclic loadings are listed hereafter:

- continuous welding
- shear connections between stiffeners and transverse frames
- soft toe brackets
- no sniped ends
- no termination on plate fields
- no scallops in critical areas
- no start and stop of welding in corners or at ends of stiffeners and brackets
- possibly grinding of toes of critical welds.

As a guidance, the following criteria may be considered:

The bending natural frequency of plates and strength members of the hull in the area of waterjets should not be less than 2.3 times the blade frequency for structures below the design waterline and between transom and aft engine room bulkhead. Structural components (such as the casing of waterjet and accessory parts and the immersed shell area) which may transfer pressure fluctuations into the ship structure have to fulfill the requirements of the waterjet manufacturer. Especially with regard the grids installed in the inlet duct, the hydrodynamic design should assure an unproblematic operation with respect to cavitation phenomenon. This checking is left to the manufacturers.

### Table 2 : Loading cases

<table>
<thead>
<tr>
<th>Component</th>
<th>LDC 1 (1)</th>
<th>LDC 2 (2)</th>
<th>LDC 3 (3)</th>
<th>LDC 4 (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built-in nozzle:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- plating</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>- bending behaviour</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship stem</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X (2)</td>
<td>X</td>
<td>X (4)</td>
<td></td>
</tr>
<tr>
<td>Bolting on stem</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X (5)</td>
<td>X</td>
<td>X (5)</td>
<td></td>
</tr>
</tbody>
</table>

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

#### 10.1.3 Waterjet supporting structure in composite materials

The supporting structure in composite materials are to be checked according the general principles defined in the present article and according to NR546 Composite Ships, Section 3.

### 11 Foils and trim tab supports

#### 11.1 General

#### 11.1.1 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 hull structure reinforcements.

As a general rule, attachment structure of foils to the hull structure are to be located within watertight compartment or equivalent.

### 12 Propeller shaft brackets

#### 12.1 General

#### 12.1.1 The scantling of propeller shaft brackets, consisting of one or two arms, are to be examined taking into account bending moment calculated in accordance with NR467 Steel Ships, Pt B, Ch 9, Sec 3.

#### 12.1.2 Scantling

For steel and aluminium propeller shaft bracket, the scantling criteria are to in accordance with the requirement defined in NR467 Steel Ships, Pt B, Ch 9, Sec 3. For aluminium, the value of $\sigma_{all}$ may be taken equal to $0.35R_y$, where $R_y$ is defined in Ch 1, Sec 2, [3.1.2].

For propeller shaft brackets built in composite materials, the scantling are to be checked by direct calculation, taking into account the checking criteria defined in Ch 2, Sec 3,
[3.1] where the Rules safety factors are to be increased by a coefficient to be taken at least equal to:

- for the main stress safety factor: 1.8
- for the combined stress safety factor: 1.5

13 Bulwarks and guard rails

13.1 Bulwarks

13.1.1 Arrangement of bulwarks
The general arrangement of bulwarks is to be as defined in NR467 Steel Ships, Pt B, Ch 9, Sec 2.

13.1.2 Scantling of bulwarks

a) Plating and secondary stiffeners
The platings and the secondary stiffeners scantling are to be as defined in Ch 4, Sec 3, [2] and Ch 4, Sec 4, [2].

b) Stays for steel and aluminium structure:
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 formulae:

- for section modulus, the greater value obtained from:
  \[ z = \frac{500p_s s^2}{\sigma_{locam}} \]
  and:
  - if $\ell \geq 0.6$ m and $s \geq 0.6$ m:
    \[ z = \frac{280p_{amin}(\ell - 0.3)}{\sigma_{locam}} \]
  - if $\ell \geq 0.6$ m and $s < 0.6$ m:
    \[ z = \frac{600p_{amin}(\ell - 0.3)}{\sigma_{locam}} \]
  - if $\ell < 0.6$ m:
    \[ z = \frac{500p_{amin}s^2}{\sigma_{locam}} \]
  with $s$ not taken greater than 0.6 m.

- for shear section, the greater value obtained from:
  \[ A_{sh} = \frac{10p_s s \ell}{\tau_{locam}} \]
  and:
  - if $\ell \geq 0.6$ m and $s \geq 0.6$ m:
    \[ A_{sh} = \frac{2.8p_{amin}}{\tau_{locam}} \]
  - if $\ell \geq 0.6$ m and $s < 0.6$ m:
    \[ A_{sh} = \frac{6.5p_{amin}}{\tau_{locam}} \]
  - if $\ell < 0.6$ m:
    \[ A_{sh} = \frac{10p_{amin}s \ell}{\tau_{locam}} \]
  with $s$ not taken greater than 0.6 m.

where:
- $p_s$ : Sea pressure on side shell as defined in Ch 3, Sec 3, [2.2.1], in kN/m$^2$, calculated at mid-height of the stay
- $p_{amin}$ : Impact pressure on side shell as defined in Ch 3, Sec 3, [3.1], in kN/m$^2$
- $s$ : Spacing of stays, in m
- $\ell$ : Length of stays, in m
- $\sigma_{locam}$, $\tau_{locam}$: Permissible stresses as defined in Ch 2, Sec 3.

c) Stays for composite structure:
The stays and their connections to the deck structure are to be examined taking into account the values of bending moments, in kN.m, and shear forces, in kN defined in NR546 Composite Ships, Sec 3, [10.2].
The scantling of the stays are to be examined as defined in NR546 Composite Ships for stiffener analysis, taking into account the safety factors defined in Ch 2, Sec 3, [3.1].

13.2 Guard rails

13.2.1 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.

14 Lifting appliances

14.1 General

14.1.1 The fixed parts of lifting appliances and their connections to the ship’s structure are covered by the Rules, 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 foundations of lifting appliances intended to be used at sea are to comply with the requirements of NR608 Classification of Lifting Units, Section 4.

14.1.2 Checking criteria
The forces and moments transmitted by the crane to the ship structure are to be submitted to the Society.
For crane not used in offshore conditions having a safe working load $F$ less than 50 kN, and when the deadweights of the crane are unknown, the bending moment $M$, in kN.m, induced by the crane pedestal to the hull is to be taken equal to:

\[ M = 2.2 F x_0 \]

where:
- $x_0$ : Maximum jib radius of the crane, in m.
For cranes having a safe working load greater than 50 kN or for crane used in offshore conditions, the bending moment and forces induced by the crane pedestal to the hull are to
be as defined in NR526 Rules for the Certification of Lifting Appliances onboard Ships and Offshore Units.

Local reinforcements and hull structure surrounding the crane pedestal are to be checked by direct calculations, taking into account the following permissible stresses:

a) For steel and aluminium structure:
\[ \sigma_{VMam} = 0.63 \, R \]
where:
\[ \sigma_{VMam} : \] Combined stress calculated according to Von Mises criteria
\[ R : \] Minimum yield stress value defined in Ch 2, Sec 3, [2.1.1].

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.

b) For composite structure:
\[ SF_{CRANE} = 1.7 \, SF \]
\[ SF_{CS\text{CRANE}} = 1.7 \, SF_{CS} \]
where:
\[ SF : \] Rules safety factor applicable to maximum stress defined in Ch 2, Sec 3, [3.2.3]
\[ SF_{CS} : \] Rules safety factor applicable to combined stress defined in Ch 2, Sec 3, [3.2.3].

15 Protection of metallic hull

15.1 General

15.1.1 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
- wooden ceiling of double bottom (see Note 1)
- wood sheathing of decks
- batten in cargo side.

Note 1: Wooden ceiling on the inner bottom is not required where the thickness of the inner bottom, calculated according to Ch 4, Sec 3, [2], is increased by 2 mm.
SECTION 3  HELICOPTER DECKS AND PLATFORMS

Symbols

\[ W_{th} \] : Maximum weight of the helicopter, in t 
\[ g \] : Gravity acceleration taken equal to 9.81 m/s\(^2\).

1 Application

1.1 General

1.1.1 The requirements of this Section apply to areas equipped for the landing and take-off of helicopters with landing gears or landing skids, and located on a deck or on a platform permanently connected to the hull structure.

1.1.2 Helicopter deck or platform intended for the landing of helicopters having landing devices other than wheels or skids are to be examined by the Society on a case-by-case basis.

1.2 Definition

1.2.1 Landing gear

A landing gear may consist of a single wheel or a group of wheels.

2 General arrangement

2.1 Landing area and approach sector

2.1.1 The main dimensions of the landing area, its location on board, the approach sector for landing and take-off are to comply with the applicable requirements from National or other Authorities.

2.1.2 The landing area and the approach sector are to be free of obstructions above the level of the helicopter deck or platform.

Note 1: The following items may exceed the height of the landing area, but not more than 100 mm:

- guttering or slightly raised kerb
- lightning equipment
- outboard edge of the safety net
- foam monitors
- those handrails and other items associated with the landing area which are incapable of complete retraction or lowering for helicopter operations.

2.2 Sheathing of the landing area

2.2.1 Within the landing area, a non-skid deck covering is recommended.

Where the helicopter deck or platform is wood sheathed, special attention is to be paid to the fire protection.

2.3 Safety net

2.3.1 It is recommended to provide a safety net at the sides of the helicopter deck or platform.

2.4 Drainage system

2.4.1 Gutterways of adequate height and a drainage system are recommended on the periphery of the helicopter deck or platform.

2.5 Deck reinforcements

2.5.1 Local deck strengthening is to be fitted at the connection of diagonals and pillars supporting platform.

3 Design loads

3.1 Emergency landing load

3.1.1 The emergency landing force \( F_{el} \) transmitted through one landing gear or one extremity of skid to the helicopter deck or platform is to be obtained, in kN, from the following formulae:

\[ F_{el} = 1.25 \, g \, W_{th} \]

The points of application of this force are to be taken so as to produce the most severe load on the supporting structure.

3.2 Garage load

3.2.1 Where a garage zone is fitted in addition to the landing area, the local forces \( F_{w} \) transmitted by one wheel or a group of wheels or one skid to the helicopter deck or platform are to be obtained, in kN, as specified in Ch 3, Sec 4, [3.3], where \( M \) is to be taken equal to:

- for helicopter with landing gears:

\[ M = \frac{1.25}{n} W_{th} \]

where \( n \) is the total number of landing gears

- for helicopter with landing skids:

\[ M = 0.5 \, W_{th} \]
3.3 Specific loads for helicopter platforms

3.3.1 The forces applied to an helicopter platform are to be determined, in kN, as follows:

- in vertical direction:
  \[ F_z = (W_{H} + W_{p})(g + a_z + 0.7 \alpha_y) + 1.2 A_{HY} \]
- in transverse direction:
  \[ F_y = 0.7(W_{H} + W_{p})a_y + 1.2 A_{HY} \]
- in longitudinal direction:
  \[ F_x = (W_{H} + W_{p})a_x + 1.2 A_{HX} \]

where:
- \( W_{H} \) : Maximum weight of the helicopter, in t
- \( W_{p} \) : Structural weight of the helicopter platform, in t,
  to be evenly distributed, and to be taken not less than the value obtained from the following formula:
  \[ W_{p} = 0.2 A_{H} \]
- \( A_{H} \) : Area, in m², of the entire landing area
- \( A_{HX}, A_{HY} \) : Vertical areas, in m², of the helicopter platform in x and y directions respectively. Unless otherwise specified, \( A_{HX} \) and \( A_{HY} \) may be taken equal to \( A_{H}/3 \)
- \( a_x \) : Longitudinal acceleration, in m/s², equal to:
  \[ a_x = 0.65 \frac{v}{T} + 0.55 \]
- \( a_y \) : Transversal acceleration, in m/s², equal to:
  \[ a_y = \alpha_z(z - T) \]
- \( a_z \) : Vertical acceleration, in m/s², as defined in Ch 3, Sec 4, [2.2]
- \( \alpha \) : Roll acceleration, in m/s², as defined in Ch 3, Sec 4, [2.1.7]
- \( y, z \) : Transversal and vertical co-ordinates, in m, of the centre of gravity of the helicopter
- \( T \) : Minimum draught of the ship, in m.

4 Local external pressures

4.1.1 Load model

The following forces \( P_0 \) are to be considered independently:
- \( P_0 = F_{EL} \)
  where \( F_{EL} \) is the force corresponding to the emergency landing load, as defined in [3.1.1]
- \( P_0 = 1.1 F_{W} \)
  where \( F_{W} \) is the forces corresponding to the garage load, as defined in [3.2.1], if applicable.

4.2 Ordinary stiffeners

4.2.1 Load model

The following forces \( P_0 \) are to be considered independently:
- \( P_0 = F_{EL} \)
  where \( F_{EL} \) is the force corresponding to the emergency landing load, as defined in [3.1.1]
- \( P_0 = 1.1 F_{W} \)
  where \( F_{W} \) is forces corresponding to the garage load, as defined in [3.2.1], if applicable
- for an helicopter platform: \( P_0 = 1.1 F_{W} \)
  where \( F_{W} \) is the forces corresponding to the garage load, as defined in [3.2.1], if applicable.

4.2.2 Normal and shear stresses

The normal stress \( \sigma \) and the shear stress \( \tau \) induced by forces defined in [4.2.1] in an ordinary stiffener of an helicopter deck or platform are obtained, in N/mm², as follows:

\[ \sigma = \frac{P_{0}l}{mW} \times 10^{3} \]
where:

\[m\] : Coefficient to be taken equal to:
- for an helicopter with wheels:
  \[m = 6\]
- for an helicopter with landing skids:
  \[m = 10\]

### 4.2.3 Checking criteria

It is to be checked that the normal stress \(\sigma\) and the shear stress \(\tau\) calculated according to [4.2.2], are in compliance with the following formulae:

\[
0.95 R_y \geq \sigma \\
0.45 R_y \geq \tau
\]

where:

\(R_y\) : Minimum yield stress, in N/mm\(^2\), of the material, as defined in:
- for steel structure:
  Ch 1, Sec 2, [2.1.5]
- for aluminium structure:
  Ch 1, Sec 2, [3.1.2]

### 4.3 Primary supporting members

#### 4.3.1 Load model

The primary structure check is to be carried out by direct calculation, taking into account the following loads considered independently:

- emergency landing load, as defined in [3.1.1]
- garage load, as defined in [3.2.1], if applicable
- for an helicopter platform, specific loads as defined in [3.3.1].

The most unfavourable case, i.e. where the maximum number of land gears is located on the same primary supporting members, is to be considered.

#### 4.3.2 Checking criteria

It is to be checked that the equivalent stress \(\sigma_{VM}\) is in compliance with the following formula:

\[
\sigma_{VM} \leq 0.95 R_y
\]

where:

\(R_y\) : Minimum yield stress, in N/mm\(^2\), of the material, as defined in [4.2.3].

When a two- or three-dimensional beam model calculation or a finite element model calculation is carried out to check the primary structure, the permissible stresses in the primary structure are defined in Ch 2, Sec 3, [2.1.1], b) and in Ch 2, Sec 3, [2.1.1], c), where \(\sigma_{VM_{min}}\) is to be taken equal to 0.95 \(R_y\).

### 5 Scantlings for composite deck structure

#### 5.1 Bending moments and transverse shear forces calculation for deck panel

5.1.1 Bending moments and transverse shear forces in deck panels are to be calculated taking into account the forces defined in [4.1] by direct calculation.

The panel analysis is to be carried out by a “ply by ply” analysis of the laminate taking into account the maximum stress criteria combined stress in each layer criteria as defined in NR546 Composite Ships, Sec 6 [5.1.2].

#### 5.2 Bending moment and shear forces calculation for secondary stiffeners

5.2.1 The bending moment \(M\), in KN.m, and the shear force \(T\), in KN, induced by forces defined in [4.2.1] in an ordinary stiffener of an helicopter deck are obtained, in N/mm\(^2\), as follows:

\[
M = \frac{P_n f}{m} \\
T = P_o
\]

where:

\(m\) : Coefficient to be taken equal to:
- for an helicopter with wheels:
  \[m = 6\]
- for an helicopter with landing skids:
  \[m = 10\]

The strains and stresses induced by the bending moment and shear force in the secondary stiffener are to be calculated as defined in NR546 Composite Ships, Sec 7 [3.1].

#### 5.3 Primary supporting members

5.3.1 The primary structure check is to be carried out by direct calculation as defined in [4.3.1].

The strains and stresses induced by the bending moment and shear force in the primary supporting members are to be calculated as defined in NR546 Composite Ships, Sec 7 [3.1].

#### 5.4 Checking criteria

5.4.1 The structure check is to be carried out as defined in NR546 Composite Ships for deck panels and stiffeners, taking into account the safety factors defined for local sea and internal pressures in Ch 2, Sec 3, [3.2]
SECTION 4  ANCHORING EQUIPMENT AND SHIPBOARD FITTINGS FOR ANCHORING, MOORING AND TOWING EQUIPMENT

Symbols

\( R_{\text{ey}} \) : Minimum yield stress, in kN/m², defined in Ch 1, Sec 2, [2]

\( R'_{\text{lim}} \) : Minimum yield stress, in kN/m², defined in Ch 1, Sec 2, [2].

1 Design assumption for anchoring equipment

1.1 General

1.1.1 The requirements of the present Section only apply to temporary anchoring of ships within a harbour or sheltered area, where the ship is awaiting for berth, tide, etc.

1.1.2 The equipment complying with these requirements is not designed to hold a ship off fully exposed coast in rough weather nor for stopping the ship 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 For ships where frequent anchoring in open sea is expected, Owner’s, shipyard’s and Designer’s attention 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 significantly reduced.

1.1.5 Anchors and chains cable components and its accessories, wire rope, etc. are to be manufactured in accordance with relevant requirements of NR216 Materials and Welding.

1.1.6 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.

1.2 General case

1.2.1 The determination of the anchoring equipment, as stipulated in [2], for ships having the navigation notation unrestricted navigation or coastal area is based on the following assumptions:

- wind speed: 50 knots (25 m/s)
- current speed: 5 knots (2.5 m/s)
- the water depth for anchoring is approximately between one tenth and one sixth of the chain cable length calculated according to [3.2.2], and
- the ship uses one anchor only under normal circumstances.

1.3 Specific cases

1.3.1 Ships with navigation notation sheltered area

The determination of the anchoring equipment, as stipulated in [2], for ships having the navigation notation sheltered area is to be based on the following assumptions:

- wind speed: 30 knots (15.5 m/s), and
- current speed: 5 knots (2.5 m/s).

Specific arrangements are defined in Ch 6, Sec 1, [17].

1.3.2 Ships with service notation seagoing launch

The determination of the anchoring equipment, as stipulated in [2], for ships having the service notation seagoing launch is to be based on the following assumptions:

- wind speed: 27 knots (14 m/s), and
- current speed: 5 knots (2,5 m/s).

Specific arrangements are defined in Ch 6, Sec 1, [17].

1.3.3 Ships with service notation launch

The determination of the anchoring equipment, as stipulated in [2] for ships having the service notation launch is to be based on the following assumptions:

- wind speed: 16 knots (8,5 m/s), and
- current speed: 5 knots (2,5 m/s).

Specific arrangements are defined in Ch 6, Sec 1, [17].

1.3.4 Ships with service notation ro-ro passenger ship or passenger ship

For ships having L ≤ 30 m, the service notation ro-ro passenger ship or passenger ship and a navigation notation other than unrestricted navigation, the determination of the anchoring equipment, as stipulated in [2], is to be based on the following assumptions:

- wind speed: 20 knots (10,5 m/s), and
- current speed: 5 knots (2,5 m/s).
1.3.5 Ships with service notation tug, salvage tug or escort tug

For ships having the service notation tug, salvage tug or escort tug, the determination of the anchoring equipment, as stipulated in [2], is to be based on the following assumptions:
- wind speed: 30 knots (15.5 m/s), and
- current speed: 5 knots (2.5 m/s).

1.3.6 Fishing vessels having the navigation notation coastal area

For fishing vessels having the navigation notation coastal area, the determination of the anchoring equipment, as stipulated in [2], may be reduced by 10%.

1.3.7 Ship for dredging activity

For ships having the service notation dredger, hopper dredger, hopper unit, split hopper dredger or split hopper unit, the equipment in chain and anchor is to be as defined in NR467 Steel Ships, Pt D, Ch 13, Sec 2.

2 Anchoring equipment calculation

2.1 General

2.1.1 All ships 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 ship in conditions as defined in Article [1].

2.1.2 For unmanned non-propelled units, the equipment is not required for classification purposes. The scantlings of anchors, chain cables and ropes to be fitted on board is the responsibility of the Designer.

2.2 Anchoring force calculation for monohull

2.2.1 Dynamic force $F_{EN}$

a) Dynamic force

The dynamic force $F_{EN}$, in kN, induced by wind and current acting on monohull in anchoring condition as defined in [2] may be calculated as follows:

$$F_{EN} = 2 \left( F_{SLPH} + F_{SH} + F_{SS} \right)$$

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 superstructures due to wind, as defined in [2.2.4].

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 ships having the service notation seagoing launch or launch
- 7.0 kN for ships having the service notation tug, salvage tug or escort tug
- 2.2 kN for ships 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:

$$F_{SLPH} = \frac{1}{2} p C_f S_m V_C^2 10^{-3}$$

where:

- $\rho$: Water density, equal to 1025 kg/m$^3$
- $C_f$: Coefficient equal to:

$$C_f = \frac{1 + k}{\log R_e - 2}$$

where:

- $R_e$: Reynolds number:
  $$R_e = \frac{V_C L WL}{1,054 \times 10^{-6}}$$
- $k$: Coefficient equal to:
  $$k = 0, 017 + 20 \frac{C_b}{L WL^{0.5} - B WL^{1.5}}$$

- $S_m$: 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 to the following formula:

$$F_{SH} = \frac{1}{2} p (C_{chf} S_{tar} + 0.2 S_{tar} + 0.02 S_{lat}) V_W^2 10^{-3}$$

where:

- $\rho$: Air density, equal to 1.22 kg/m$^3$
- $V_W$: Speed of the wind, in m/s, as defined in [1]
- $S_{chf}$: Front surface of hull and bulwark if any, in m$^2$, projected on a vertical plane perpendicular to the longitudinal axis of the ship
- $S_{tar}$: Alt hull transom surface and bulwark if any, in m$^2$, projected on a vertical plane perpendicular to the longitudinal axis of the ship
- $S_{lat}$: 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 axis of the ship and delimited according to Fig 1

$$C_{chf} = 0.8 \sin \alpha$$

Note 1: In Fig 1, B is the breadth of the hull, in m.
2.2.4 Static forces $F_{SS}$ on superstructures and deckhouses

a) General case:

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 to the following formula:

$$F_{SS} = \frac{1}{2} \rho \Sigma (C_{sfri} S_{sfri} + C_{sar i} S_{sar i} + 0.08 S_{slati}) V_{W}^2 \cdot 10^{-3}$$

where:
- $\rho$ : Air density, equal to 1.22 kg/m$^3$
- $V_{W}$ : 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 m$^2$, projected on a vertical plane perpendicular to the longitudinal axis of the ship
- $S_{sar i}$ : Aft surface of tier i (superstructure or deckhouse, including bulwark if any), in m$^2$, projected on a vertical plane perpendicular to the longitudinal axis of the ship
- $S_{slati}$ : Partial lateral surface of one single side of tier i (superstructure or deckhouse, including bulwark if any), in m$^2$, projected on a vertical plane parallel to the longitudinal axis of the ship
- $C_{sfri} = 0.8 \sin \beta_i$, with $\beta_i$ defined in Fig 1
- $C_{sar i} = 0.8 \sin \gamma_i$, with $\gamma_i$ defined in Fig 1

C$_{sfri}$ = 0.8 sin $\beta_i$, with $\beta_i$ defined in Fig 1

b) Superstructures in the forward part of the ship:

Where superstructures are located in the front of the hull with front and side walls of superstructures in the continuity of the side shell, the static force induced by wind applied on these superstructures, in kN, is defined as the sum of the forces applied to each superstructure tier according to the following formula:

$$F_{SS} = \frac{1}{2} \rho \Sigma (C_{sfri} S_{sfri} + C_{sar i} S_{sar i} + 0.08 S_{slati}) V_{W}^2 \cdot 10^{-3}$$

where:
- $S_{sfri}$ : Front surface of tier i of the superstructure, in m$^2$
- $C_{sfri} = 0.8 \sin \alpha$, with $\alpha$ measured as defined in Fig 1 at mid height of the superstructure tier
- $\rho, V_{W}, S_{sfri}, S_{sar i}, C_{sar i}$: As defined in [2.2.4] a).

The static force is to be added to the static force calculated for the other superstructures and deckhouses according to [2.2.4] a).

2.3 Anchoring force calculation for multihull

2.3.1 The dynamic force, in kN, induced by wind and current acting on multihull in anchoring condition as defined in [1.2.1] may be calculated as defined in [2.2] with the following particular assumptions for the calculation of the static forces on the:

- wetted part of the hull
  - $F_{SLPH}$ : As defined in [2.2.2], taking into account the two floats for the calculation of the total wetted surface $S_{in}$
- hull
  - $F_{Sh}$ : As defined in [2.2.3], taking into account:
    - the two floats for the calculation of $S_{bar}$
    - the two floats transom and the aft surface of the aft transversal main beam between the floats for the calculation of $S_{bar}$
    - one single side of one float for the calculation of $S_{slati}$ (“B” on Fig 1 is to be taken as the breadth of one float).
- superstructure
  - $F_{SS}$ : As defined in [2.2.4], taking also into account the frontal surface of the platform.
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:
- for ordinary anchor: \( P = \frac{F_{EN}}{7} \cdot 10^2 \)
- for high holding power anchor: \( P = \frac{F_{EN}}{10} \cdot 10^2 \)
- for very high holding power: \( P = \frac{F_{EN}}{15} \cdot 10^2 \)

3.1.2 Number of anchors
As a rule, the number of anchors to be provided on board is to be at least:
- a) General case
  - 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 between 4,5 kN and 45 kN
Note 1: For ships with \( F_{EN} \), between 4,5 and 9,0 kN, the second anchor may also be dispensed (except for passenger ship or ro-ro passenger ship having a navigation notation unrestricted navigation). 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.
- three anchors, when the dynamic force \( F_{EN} \) calculated according to [2.2] is greater than 45 kN.
Note 2: In this case, two anchors are to be connected to their own chain cables and positioned on board always ready to use. The third anchor is intended as a spare one and is not required for the purpose of classification.
- b) Ships having \( L \leq 30 \) m, the service notation ro-ro passenger ship or passenger ship and a navigation notation other than unrestricted navigation
  - one anchor
- c) Ships with service notation seagoing launch or launch
  Ships with \( F_{EN} \) less than 4,7 kN are not required to carry a second anchor, except in the case of passenger launch. For ships with \( F_{EN} \) between 4,7 kN and 9,0 kN, the second anchor may also be dispensed, except for passenger launch. In this case, the weight of the anchor is to be increased by one third and the length and size of the chain cable are to correspond to the increased weight of the anchor according to [3.2.2].
- d) Ships with service notation tug, salvage tug or escort tug:
  A reduction of number of anchors may be accepted according to Ch 6, Sec 1, [18.4].

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 the Society requirements.
A high or very high holding power anchor is 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 4, Sec 1, [1.5.2].
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 HHHP 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 the relevant requirements of NR216 Materials and Welding.
Tests and examination requirements are to comply with NR216 Materials and Welding, Ch 4, Sec 1, [1.5].
3.2 Chain cables

3.2.1 Stud link chain cable scantling

Chain cable diameter, type and steel grades are to be as defined in Tab 1, according to the minimum breaking load BL and proof load PL, in kN, defined according to the following formulae:

- for steel grade Q₁:
  \[ BL = 3 F_{EN} \]
  \[ PL = 0.7 BL \]

- for steel grade Q₂:
  \[ BL = 3.4 F_{EN} \]
  \[ PL = 0.7 BL \]

- for steel grade Q₃:
  \[ BL = 3.75 F_{EN} \]
  \[ PL = 0.7 BL \]

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].

As a rule, the minimum diameter, in mm, corresponding to a quality Q₁, is not to be less than:

- 11 in a general case
- 7 for ships having \( L \leq 30 \text{ m} \), the service notation tug, salvage tug or escort tug, and a navigation notation other than unrestricted navigation.

3.2.2 Length of individual chain cable

The length of chain cable \( L_{cc} \), in m, linked to each anchor is to be at least equal to:

a) General case:
  \[ L_{cc} = 30 \ln(P) - 42 \]
b) For ship having the service notation tug, salvage tug or escort tug:
  \[ L_{cc} = 0.15 P + 40 \]

where:

- \( P \): Anchor weight, in kg, defined in [3.1.1] for an ordinary anchor according to the considered case.

The minimum length of chain cable on board is to be in accordance with the water depth of anchoring as specified in [1.2.1].

3.2.3 Chain cables arrangements

Chain cables are to be made by lengths of 27.5 m each, joined together by Dee or lugless shackles.

Normally grade Q₂ or Q₃ for stud link chain cables and SL2 or SL3 for studless chain cables are to be used with HHP and VHHP 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 4, Sec 1.

<table>
<thead>
<tr>
<th>Chain diameter (mm)</th>
<th>Proof load (kN)</th>
<th>Breaking load (kN)</th>
<th>Proof load (kN)</th>
<th>Breaking load (kN)</th>
<th>Proof load (kN)</th>
<th>Breaking load (kN)</th>
<th>Minimum mass per meter length (kg/m)</th>
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<td>102</td>
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<td>46</td>
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<td>896</td>
<td>1280</td>
<td>33.8</td>
</tr>
</tbody>
</table>
### 3.2.4 Studless link chain cables

For ships with $F_{SN}$ 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].

### 3.3 Wire ropes and synthetic fibre ropes

#### 3.3.1 As an alternative to the chain cable, wire ropes or synthetic fibre ropes may be used in the following cases:

- for both anchors, for ship length less than 30 m
- for one of the two anchors, for ship length between 30 m and 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] 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.

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
- $P_R = 1.2 \times BL$ for synthetic fibre rope,

where BL, in kN, is the required breaking load defined in [3.2.1] of the replaced chain cable.

#### 3.3.2 For ships with service notation tug, salvage tug or escort tug, see Ch 6, Sec 1, [18.4].

### 3.4 Attachment pieces

#### 3.4.1 Both attachment pieces and connection fittings for chain cables are to be designed and constructed in such 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 The anchor windlasses are to comply with NR626 Anchor Windlass.

4.1.2 Brake capacity
The windlass brake is to be sufficient to withstand the following loads:
- 0.8 time the breaking load BL of the chain defined in [3.2.1], if not combined with a chain stopper,
- 1.2 time the value of $F_{EN}$ defined in [2.2.1] if combined with a chain stopper.

4.1.3 Chain stopper
When a chain stopper is fitted, it is to be able to withstand a pull of 80% of the breaking load of the chain, without any permanent deformation of the stresses parts.

4.1.4 Deck reinforcement under windlass and chain stopper
Local reinforcement of deck structure are to be provided in way of windlass and chain stopper, and designed in accordance with NR626 Anchor Windlass for steel and aluminium structure.

For composite materials structure, local reinforcement structure are to designed in accordance with:

a) Windlass without chain stopper: Brake capacity as defined in [4.1.2] taking into account safety factors equal to SF and SF$_{CS}$

b) Windlass combined with chain stopper:
   1) Windlass: Brake capacity as defined in [4.1.2] taking into account safety factors equal to 0.7 SF and 0.7 SF$_{CS}$
   2) Chain stopper: Design load defined in [4.1.3] taking into account safety factors equal to SF and SF$_{CS}$

where:

SF : Safety factor for structure checked with minimum stress criteria in layers as defined in Ch 2, Sec 3, [3.2.3]

SF$_{CS}$ : Safety factor for structure checked with combined stress criteria in layers as defined in Ch 2, Sec 3, [3.2.3].

4.2 Chain locker

4.2.1 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 fittings for towing and mooring

5.1 General

5.1.1 The equipment for mooring and or towing are not covered within the scope of classification.

However, deck reinforcements under mooring and towing equipment such as, bitts, bollard, fairleads, chocks... are to be examined within the scope of hull drawing examination.

For ships of 500 GT and above, the requirements of NR467 Steel Ships, Pt B, Ch 9, Sec 4, [5] are to be applied, considering an equivalent equipment number EN equal to five times the value of $F_{EN}$ as calculated in [2.2.1].

5.1.2 Documents to be submitted
Maximum safe working 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 loads and the manner of applying mooring and towing lines (including line angles).

5.1.3 Hull structure reinforcement
As a general rule, hull structure reinforcements in way of mooring and towing equipment are to be examined by direct calculation, taking into account:

- a tension in the mooring or towing line equal to the safe working load of the equipment, and
- the permissible stresses and safety factors as defined in Ch 2, Sec 3.

Note 1: 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.
ADDITIONAL REQUIREMENTS IN RELATION TO THE SERVICE NOTATION OR SERVICE FEATURE ASSIGNED TO THE SHIP

SECTION 1  ADDITIONAL REQUIREMENTS IN RELATION TO THE SERVICE NOTATION OR SERVICE FEATURE ASSIGNED TO THE SHIP
SECTION 1  ADDITIONAL REQUIREMENTS IN RELATION TO THE SERVICE NOTATION OR SERVICE FEATURE ASSIGNED TO THE SHIP

Symbols

\[ \text{L}_{\text{WL}} : \text{Ship's length at waterline, in m} \]
\[ \text{L} : \text{Reference ship's length, to be taken equal to } \text{L}_{\text{WL}} \]
\[ k : \text{Material factor as defined in Ch 1, Sec 2} \]
\[ s : \text{Length, in m, of the shorter side of the plate panel or spacing, in m, of secondary stiffeners, or spacing, in m, of primary supporting members, as applicable.} \]

1 General

1.1 Service notations and service features

1.1.1 Definition

The service notations define the type and/or service of the ship which is considered for its classification.

A service notation may be completed by one or more additional service features giving further precision regarding the type of service of the ship.

The service notation and the additional service features are defined in NR467 Steel Ships, Pt A, Ch 1, Sec 2, [4].

1.1.2 Application and additional requirements

The present Section defines the hull arrangement and hull structure requirements to be considered in relation to the service notation or service feature assigned to the ship and to be applied in addition to the other requirements of the present Rules.

When specified in the present Section, requirements defined in NR467 Steel Ships, Part D or Part E are to be considered for the hull arrangement and hull structure.

For information, requirements defined in NR467 Steel Ships, Part D or Part E may be also required for stability, machinery and electrical installations and fire protection.

Cross references between the present Section and NR467 Steel Ships are given in Tab 1 for information.

1.1.3 Documentation to be submitted

The plans and documents to be submitted to the Society in relation to the service notation or service feature considered are listed in the Chapters of NR467 Steel Ships, Part D or Part E as given in Tab 1.

1.1.4 Ship types not covered by the present Rules

Ship types not covered by the present Rules are defined in Ch 1, Sec 1, [1.2].

Table 1 : List of articles in relation to the service notation or additional service feature

<table>
<thead>
<tr>
<th>Service notation or additional service feature</th>
<th>Reference of Article</th>
<th>Reference Chapter in NR467</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ro-ro cargo ship and pure car / truck carriers</td>
<td>[2]</td>
<td>Part D, Chapter 1</td>
</tr>
<tr>
<td>Container ships</td>
<td>[3]</td>
<td>Part D, Chapter 2</td>
</tr>
<tr>
<td>Livestock carriers</td>
<td>[4]</td>
<td>Part D, Chapter 3</td>
</tr>
<tr>
<td>Bulk carriers</td>
<td>[5]</td>
<td>Part D, Chapter 4</td>
</tr>
<tr>
<td>Ore carriers</td>
<td>[6]</td>
<td>Part D, Chapter 5</td>
</tr>
<tr>
<td>Combination carriers</td>
<td>[7]</td>
<td>Part D, Chapter 6</td>
</tr>
<tr>
<td>Oil tankers and FLS tankers</td>
<td>[8]</td>
<td>Part D, Chapter 7</td>
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<td>Chemical tankers</td>
<td>[9]</td>
<td>Part D, Chapter 8</td>
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<td>Tankers</td>
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<td>Ro-ro passenger ships</td>
<td>[12]</td>
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<td>Part D, Chapter 15</td>
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<td>Offshore patrol vessels</td>
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<td>Part D, Chapter 16</td>
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<td>Launch and Seagoing launch</td>
<td>[17]</td>
<td>–</td>
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<tr>
<td>Tugs</td>
<td>[18]</td>
<td>Part E, Chapter 1</td>
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<td>Part E, Chapter 2</td>
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<td>Part E, Chapter 3</td>
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<td>Fire-fighting ships</td>
<td>[21]</td>
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<td>Oil recovery ships</td>
<td>[22]</td>
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<td>Cable-laying ships</td>
<td>[23]</td>
<td>Part E, Chapter 6</td>
</tr>
<tr>
<td>Diving support vessels</td>
<td>[24]</td>
<td>Part E, Chapter 7</td>
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<tr>
<td>Lifting units</td>
<td>[25]</td>
<td>Part E, Chapter 8</td>
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<tr>
<td>Semi-submersible cargo ships</td>
<td>[26]</td>
<td>Part E, Chapter 9</td>
</tr>
<tr>
<td>Standby rescue vessels</td>
<td>[27]</td>
<td>Part E, Chapter 10</td>
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<tr>
<td>Accommodation units</td>
<td>[28]</td>
<td>Part E, Chapter 11</td>
</tr>
<tr>
<td>Pipe-laying units</td>
<td>[29]</td>
<td>Part E, Chapter 12</td>
</tr>
</tbody>
</table>
2 Ro-ro cargo ships and pure car/truck carriers

2.1 Application

2.1.1 Ships having the service notation ro-ro cargo ship or PCT carrier are to comply with the requirements of the present Article.

2.2 General

2.2.1 Wood sheathing
Wood sheathing is recommended for caterpillar trucks and unusual vehicles.

2.2.2 Global transverse strength
When deemed necessary by the Society, the behaviour of the ship primary structural members under racking effect due to transverse forces induced by transverse accelerations is to be investigated by direct calculation on a case by case basis.

2.3 Hull scantlings for steel structure

2.3.1 Plating
The thickness of the weather strength deck and trunk deck plating is to be not less than the values obtained, in mm, from the following formula:

\[ t = 3.6 + 0.013 L + 4.5 s \]

where:

- \( s \) : Length, in m, of the shorter side of the plate panel.

2.3.2 Inner bottom of cargo holds intended to carry dry cargo
The inner bottom thickness calculated as defined in Ch 4, Sec 3, [2] is to be increased by 2 mm unless it is protected by a continuous wooden ceiling.

3 Container ships

3.1 Application

3.1.1 Ships having the service notation container ship and ships assigned with the additional service feature equipped for carriage of containers are to comply with the requirements of the present Article.

3.1.2 The additional requirements of this Article apply to container ships intended to carry containers in holds and/or on deck.

3.2 Structure design principles

3.2.1 General strength principles
Local reinforcements of the hull structure are to be provided under container corners and in way of fixed cargo securing devices and cell guides, if fitted.

The forces applying on the fixed cargo securing devices are to be indicated by the Designer. When one of the additional class notations LASHING, LASHING-WW or LASHING (restricted area) is granted, these forces may be determined by the Society.

3.2.2 Structural continuity
On double hull ships, where the machinery space is located between two holds, the inner side is, in general, to be continuous within the machinery space. Where the machinery space is situated aft, the inner hull is to extend as far abaft as possible and be tapered at the ends.

3.2.3 Bottom structure
a) Floor and girder spacing:
   The floor spacing is to be such that floors are located in way of the container corners. Floors are also to be fitted in way of watertight bulkheads.
   Girders are generally to be fitted in way of container corners.

b) Reinforcement in way of cell guides:
   The structure of the bottom and inner bottom on which cell guides rest is to be adequately stiffened with doublers, brackets or other equivalent reinforcements.

3.2.4 Side structure
The topside torsion box girders are to be longitudinally framed.
Where the side is longitudinally framed, side transverse structure is to be fitted in line with the double bottom floors.

3.2.5 Deck structure
a) Longitudinal girders between hatchways:
   The width of the longitudinal deck girders and hatch coaming flanges is to be such as to accommodate the hatch covers and their securing arrangements.
   The connections of the longitudinal deck girders and hatch coamings with the machinery space structure, and aft and fore part structures are to ensure proper transmission of stresses from the girders to the adjacent structures.

b) Cross decks:
   Cross decks between hatches are subject to a shear force in the longitudinal direction induced by the overall torsion of the ship. The adequate strength of these deck strips is to be checked in that respect.
   Cross decks between hatches are to be suitably overlapped at ends.

c) Deck and hatch cover reinforcements:
   Deck or hatch cover structures are to be reinforced taking into account the loads transmitted by the corners of containers and cell guides.

3.2.6 Bulkhead structure
a) Transverse box structures in way of transverse watertight bulkheads:
   Bottom and top transverse box structures are generally to be provided in way of transverse watertight bulkheads at the inner bottom and deck level, respectively.
b) Primary supporting members:
   The vertical primary supporting members of transverse
   watertight bulkheads are to be fitted in line with the
deck girders and the corresponding bottom girders.

c) Reinforcements in way of cell guide:
   When cell guides are fitted on transverse or longitudinal
   bulkheads which form boundaries of the hold, such struc-
tures are to be adequately reinforced taking into account
the loads transmitted by cell guides.

3.2.7  Cell guides
   Arrangement of fixed cell guides is to be as defined in
NR467 Steel Ships, Pt D, Ch 2, Sec 2, [2.4].

3.3 Design loads

3.3.1  Forces on containers
   a) Still and inertial forces:
      The vertical forces $F_{Z,i}$ and transversal forces $F_{T,i}$ in kN,
applied to the containers at each level “i” of a stack are
to be calculated as defined in Ch 3, Sec 4, [3.2.3] for
the dry unit cargo, where $M$, in t, is to be taken equal
the mass of the container.
   Where empty containers are stowed at the top of a
stack, the forces are to be calculated considering weight
of empty containers equal to:
   - 0.14 times the weight of a loaded container, in the
case of steel containers
   - 0.08 times the weight of a loaded container, in the
case of aluminium containers.

   b) Wind forces:
      The forces $F_{wind,i}$ in y direction applied to one con-
tainer stowed above deck at the level “i” due to the
effect of the wind is to be obtained, in kN, from the fol-
lowing formula:
      $$F_{wind,i} = 1.2 h_C \cdot \ell_C$$
      where:
      $h_C$ : Height, in m, of a container
      $\ell_C$ : Dimension, in m, of the container stack in
      the ship longitudinal direction.

   c) Reaction at the corners of stacks of containers:
      The reaction at the corner of stack are to be calculated
in the two following conditions of navigation:
      - ship in upright condition (see Fig 1)
      - ship in inclined condition (see Fig 2).
      The forces to be considered as being applied at the cen-
tre of gravity of the stack, the reactions at the corners of
stack are to be obtained, in kN, as specified by the fol-
lowing formulae:
      - in upright condition:
        $$R_{W,i} = R_{W,z} = \frac{F_{W,Z}}{4}$$
      - in inclined condition:
        $$R_{W,i} = \frac{F_{W,Z}}{4} + \frac{Nh_b F_{W,Y}}{4b_C}$$

   where:
   $F_{W,Z}$ : Vertical force in a stack, in kN:
   $$F_{W,Z} = \sum_{i=1}^{N} F_{Z,i}$$
   $F_{W,Y}$ : Horizontal force in a stack, in kN:
   $$F_{W,Y} = \sum_{i=1}^{N} (F_{T,i} + F_{Y,wind,i})$$
   $F_{Z,i}$, $F_{T,i}$ : Vertical and transversal forces, in kN, as
defined in item a)
   $N$ : Number of container per stack.

3.4 Hull girder scantling

3.4.1 General
   For container ships carrying containers in holds, the hull
girder strength under still and wave torsional moments is to
be examined on a case by case basis.
4 Livestock carriers

4.1 Application

4.1.1 Ships having the service notation livestock carrier are to comply with the requirements of the present Article.

4.2 General arrangement design

4.2.1 General arrangement design is to be as defined in NR467 Steel Ships, Pt D, Ch 3, Sec 2, [2].

4.3 Hull girder strength and hull scantlings

4.3.1 Hull girder strength

In general, the decks and platform decks above the strength deck used for the carriage of livestock may not be taken into account for the calculation of the section modulus.

4.3.2 Movable or collapsible structural elements above the strength deck

In general, the movable or collapsible structural elements above the strength deck used for the stocking and the distribution of livestock on decks or platform decks are not a part of ship classification.

5 Bulk carriers

5.1 Application

5.1.1 Ships having one of the service notations bulk carrier ESP or bulk carrier are to comply with the requirements of the present Article.

5.1.2 As a rule, the hull structure of ships whose service notation is completed by the additional service feature non-homload as defined in NR467 Steel Ships, Pt D, Ch 4, Sec 3, [3.1.2], is to be checked according to NR467 Steel Ships, Part B instead of the present Rules.

5.2 Ship arrangement

5.2.1 Specific ship arrangement is to comply with requirements defined in NR467 Steel Ships, Pt D, Ch 4, Sec 2.

5.3 Structure design principles

5.3.1 Structure design principles defined in NR467 Steel Ships, Pt D, Ch 4, Sec 3, [2], are applicable.

5.4 Design loads

5.4.1 Application

In addition to the requirements of Chapter 3, the loading conditions, subdivided into departure and arrival conditions, defined in NR467 Steel Ships, Pt D, Ch 4, Sec 3, [3.1.2] are to be taken into account for hull girder strength and local strength analysis according to the present Rules.

5.4.2 Additional requirements on local loads for ships with the additional service feature heavycargo

For ships with a service notation completed by the additional service feature heavycargo [AREA1, X1 kN/m² - AREA2, X2 kN/m² - ...] as defined in NR467 Steel Ships, Part A the values of \( P_{bp} \) used to calculate the dry uniform cargo as defined in Ch 3, Sec 4, [3.2.2], in kN/m², are to be specified by the Designer for each AREAi, and introduced as Xi values in the above service feature.

5.4.3 Loading conditions for primary structure analysis

The following loading conditions are to be considered in the analysis of the primary structure:

- homogeneous loading and corresponding draught \( T \)
- heavy ballast (the ballast hold being full) and corresponding draught \( T \).

5.5 Hull scantlings for steel structure

5.5.1 Plating

As a rule, the thickness of the side plating located between hopper and topside tanks, in mm, is to be not less than:

\[ t_{MIN} = L^{0.5} + 2 \]

5.5.2 Inner bottom of cargo holds intended to carry dry cargo

The inner bottom thickness calculated as defined in Ch 4, Sec 3, [2] is to be increased by 2 mm unless it is protected by a continuous wooden ceiling.

5.5.3 Secondary stiffeners

The thicknesses of side frames and their brackets, in way of cargo holds, are to be not less than the values given in Tab 2.

<table>
<thead>
<tr>
<th>Item</th>
<th>Minimum thickness, in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side frame webs</td>
<td>( C_i ) ((7,0 + 0,03 \ L_{w1}) + 1,75 )</td>
</tr>
<tr>
<td>Lower end bracket</td>
<td>The greater of the following: ( C_i ) ((7,0 + 0,03 \ L_{w1}) + 3,75 ) ( + ) as fitted thickness of side frame web</td>
</tr>
<tr>
<td>Upper end bracket</td>
<td>The greater of the following: ( C_i ) ((7,0 + 0,03 \ L_{w1}) + 1,75 ) ( + ) as fitted thickness of side frame web</td>
</tr>
</tbody>
</table>

Note 1:

- \( C_i \): Coefficient equal to:
  - 1.15 for side frames in way of the foremost cargo hold
  - 1 for side frames in way of the other cargo holds.
5.5.4 Scantlings of side frames adjacent to the collision bulkhead

The scantlings of side frames in way of the foremost cargo hold and immediately adjacent to the collision bulkhead are to be increased by 25% with respect to those determined according to Chapter 4, in order to prevent excessive imposed deformation on the side shell plating.

As an alternative, supporting structures are to be fitted which maintain the continuity of fore peak girders within the foremost cargo hold.

5.6 Hatch covers

5.6.1 Steel large hatch covers are to be as defined in NR467 Steel Ships, Pt D, Ch 4, Sec 4.

5.7 Protection of hull metallic structure

5.7.1 Protection of cargo hold is to be as defined in NR467 Steel Ships, Pt D, Ch 4, Sec 3, [7].

In these requirements, references to NR467, Part B are to be replaced by the equivalent requirements defined in the present Rules.

5.8 Construction and testing

5.8.1 Construction and testing are to fulfil the requirements of NR467 Steel Ships, Pt D, Ch 4, Sec 3, [8].

6 Ore carriers

6.1 Application

6.1.1 Ships having the service notation ore carrier are to comply with the requirements of the present Article.

6.1.2 As a rule, for ships having alternate light and heavy cargo loading conditions, the hull scantlings are to be checked according to NR467 Steel Ships, Part B instead of the present Rules.

6.2 Ship arrangement

6.2.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 5, Sec 2.

6.3 Structure design principles

6.3.1 Structure design principle defined in NR467 Steel Ships, Pt D, Ch 5, Sec 3, [3] are applicable.

6.4 Design loads

6.4.1 Application

In addition to the requirements of Chapter 3, the loading conditions, subdivided into departure and arrival conditions, defined in NR467 Steel Ships, Pt D, Ch 5, Sec 3, [4.1.1] are applicable for hull girder and primary structure analysis according to the present Rules.

6.5 Hull scantlings for steel structure

6.5.1 Minimum thickness of the inner bottom plating in holds

The inner bottom thickness calculated as defined in Ch 4, Sec 3, [2] is to be increased by 2 mm unless it is protected by a continuous wooden ceiling.

As a rule, the minimum thickness, in mm, of the inner bottom plating in holds is not to be less than:

\[ t_{MIN} = 2.15 \left( L_{WL}^{1/3} k_{1/6} \right) + 4.4 s + 2 \]

where:

\[ s \] : Length, in m, of the shorter side of the plate panel.

6.5.2 Strength checks of cross-ties analysed through a three dimensional beam analysis

Cross-tie analysis is to be carried out as defined in NR467 Pt D, Ch 5, Sec 3, [5.3].

6.6 Hatch covers

6.6.1 Steel large hatch covers are to be as defined in NR467 Steel Ships, Pt D, Ch 4, Sec 4 for hatch covers of ships having the service notation bulk carrier.

6.7 Construction and testing

6.7.1 Construction and testing are to fulfil the requirements of NR467 Steel Ships, Pt D, Ch 5, Sec 3, [7].

In these requirements, references to NR467, Part B are to be replaced by the equivalent requirements defined in the present Rules.

7 Combination carriers

7.1 Application

7.1.1 Ships having the service notation combination carrier are to comply with the requirements of the present Article.

7.1.2 As a rule, for ships having alternate light and heavy cargo loading conditions, the hull scantlings are to be checked according to NR467 Steel Ships, Part B instead of the present Rules.

7.2 Ship arrangement

7.2.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 6, Sec 2.

7.3 Structure design principles

7.3.1 As far as practicable, structure design principles are to be examined on the basis of the requirements defined in NR467 Steel Ships, Pt D, Ch 6, Sec 3, [3] and Pt D, Ch 6, Sec 3, [4] for ships having the service notation combination carrier/OBO ESP and combination carrier/OOC ESP respectively.
7.4 Design loads

7.4.1 Application
In addition to the requirements of Chapter 3, the loading conditions, subdivided into departure and arrival conditions, defined in NR467 Steel Ships, Pt D, Ch 6, Sec 3, [5.1.1] are applicable.

7.4.2 Oil cargo mass density
In the absence of more precise values, an oil cargo mass density of 0.9 t/m³ is to be considered for calculating the internal pressures and forces in cargo tanks according to Ch 3, Sec 4.

7.5 Hull scantlings for steel structure

7.5.1 Plating
As a rule, the thickness of the plating of the inner bottom in holds intended to carry ore, of the strength deck and of bulkheads is to be not less than the values given in Tab 3.

<table>
<thead>
<tr>
<th>Table 3 : Minimum plating thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plating</td>
</tr>
<tr>
<td>Strength deck</td>
</tr>
<tr>
<td>Inner bottom in holds</td>
</tr>
<tr>
<td>intended to carry ore</td>
</tr>
<tr>
<td>Tank bulkhead</td>
</tr>
<tr>
<td>Watertight bulkhead</td>
</tr>
</tbody>
</table>

Note 1: s : Length, in m, of the shorter side of the plate panel

7.5.2 Secondary stiffeners
The thickness of the web of secondary stiffeners is to be not less than the value obtained, in mm, from the following formula:

\[ t_{MIN} = 0,75 \ L^{1/3} \ k^{1/6} + 4,5 \ s + 3 \]

where s is the spacing, in m, of secondary stiffeners.

7.5.3 Primary stiffeners
a) Minimum thickness:
The thickness of plating which forms the webs of primary supporting members is to be not less than the value obtained, in mm, from the following formula:

\[ t_{MIN} = 1,45 \ \ L^{1/3} \ k^{1/6} + 3 \]

b) Strength check of primary structure through a three-dimensional beam model:
Where the primary structure is checked through a three dimensional beam model, the requirements of NR467 Steel Ships, Pt D, Ch 6, Sec 3, [6.3] are to be applied.

7.5.4 Strength check with respect to stresses due to the temperature gradient
Direct calculations of stresses induced in the hull structures by the temperature gradient are to be performed for ships intended to carry cargoes at temperatures exceeding 90°C. In these calculations, the water temperature is to be assumed equal to 0°C.

The calculations are to be submitted to the Society for review.

7.6 Other structures

7.6.1 Inner bottom of cargo holds intended to carry dry cargo
The inner bottom thickness for steel structure calculated as defined in Ch 4, Sec 3, [2] is to be increased by 2 mm unless it is protected by a continuous wooden ceiling.

7.6.2 Machinery space and opening arrangement are to be in accordance with the requirements of NR467 Steel Ships, Pt D, Ch 6, Sec 3, [7].

7.6.3 Steel large hatch covers are to be as defined in NR467 Steel Ships, Pt D, Ch 4, Sec 4 for hatch covers of ships having the service notation bulk carrier.

7.7 Protection of hull metallic structures

7.7.1 Requirements of NR467 Steel Ships, Pt D, Ch 6, Sec 3, [9] are applicable.

7.8 Cathodic protection of tanks

7.8.1 Requirements of NR467 Steel Ships, Pt D, Ch 6, Sec 3, [10] are applicable.

7.9 Construction and testing

7.9.1 Requirements of NR467 Steel Ships, Pt D, Ch 6, Sec 3, [11] are applicable.

In these requirements, references to NR467, Part B are to be replaced by the equivalent requirements defined in the present Rules.

8 Oil tankers and FLS tankers

8.1 Application

8.1.1 Ships having the service notation oil tanker are to comply with the requirements of the present Article, taking into account the general requirements defined in NR467 Steel Ships, Pt D, Ch 7, Sec 1.

8.1.2 As a rule, for ships having non homogeneous loading conditions, the hull scantlings are to be checked according to NR467 Steel Ships, Part B instead of the present Rules.

8.2 Ship arrangement

8.2.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 7, Sec 2.

8.3 Design loads

8.3.1 Application
In addition to the requirements of Chapter 3, the hull girder load conditions, subdivided into departure and arrival conditions, defined in NR467 Steel Ships, Pt D, Ch 7, Sec 3, [4.1.1] are applicable.
8.3.2 Cargo mass density
In the absence of more precise values, a cargo mass density of 0.9 t/m³ is to be considered for calculating the internal pressures and forces in cargo tanks according to Ch 3, Sec 4.

8.3.3 Partial filling
The carriage of cargoes with a mass density above the one considered for the design of the cargo tanks may be allowed with partly filled tanks under the conditions stated in the NR467 Steel Ships, Pt B, Ch 5, Sec 6, [2]. The classification certificate or the annex to this certificate is to mention these conditions of carriage.

8.3.4 Overpressure due to cargo filling operations
For ships having the additional service feature asphalt carrier, the overpressure which may occurred under loading/unloading operations are to be considered, if any. In such a case, the diagram of the pressures in loading/unloading conditions is to be given by the Designer.

8.3.5 Loading conditions for primary structure
The loading conditions for the analysis of primary structure are to be defined in NR467 Steel Ships, Pt D, Ch 7, Sec 3, [5.3.2].

8.4 Hull scantlings for steel structure

8.4.1 Plating
The thickness of the strength deck and bulkhead plating is to be not less than the values given in Tab 4.

<table>
<thead>
<tr>
<th>Plating</th>
<th>Minimum thickness in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength deck</td>
<td>(5,5 + 0,02 L) k1/2 + 1,5</td>
</tr>
<tr>
<td>Tank bulkhead</td>
<td>L1/3 k1/6 + 4,5 s + 1</td>
</tr>
<tr>
<td>Watertight bulkhead</td>
<td>0,85 L1/3 k1/6 + 4,5 s + 1</td>
</tr>
</tbody>
</table>

Note 1: s : Length, in m, of the shorter side of the plate panel

8.4.2 Secondary stiffeners
The thickness of the web of secondary stiffeners is to be not less than the value obtained, in mm, from the following formula:

\[ t_{\text{MIN}} = 0.75 \cdot L^{1/3} \cdot k^{1/6} + 4.5 \cdot s + 1 \]

where \( s \) is the spacing, in m, of secondary stiffeners.

8.4.3 Primary stiffeners
a) Minimum thickness
The thickness of plating which forms the webs of primary supporting members is to be not less than the value obtained, in mm, from the following formula:

\[ t_{\text{MIN}} = 1.45 \cdot L^{1/3} \cdot k^{1/6} + 1 \]

b) Strength check of primary structure through a three-dimensional beam model

Where the primary structure is checked through a three-dimensional beam model, the following requirements of NR467 Steel Ships are to be applied:

- Pt D, Ch 7, Sec 3, [5.3.3] for floors of cargo tank with hopper tank
- Pt D, Ch 7, Sec 3, [5.3.4] for cross-ties
- Pt D, Ch 7, Sec 3, [5.3.5] for cross-ties when a finite element model is carried out.

8.4.4 Strength check with respect to stresses due to the temperature gradient
Direct calculations of stresses induced in the hull structures by the temperature gradient are to be performed for ships intended to carry cargoes at temperatures exceeding 90°C. In these calculations, the water temperature is to be assumed equal to 0°C. The calculations are to be submitted to the Society for review.

8.5 Other structures
8.5.1 Machinery space and opening arrangement are to be in accordance with the requirements of NR467 Steel Ships, Pt D, Ch 7, Sec 3, [6].

8.6 Protection of hull metallic structure
8.6.1 Requirements of NR467 Steel Ships, Pt D, Ch 7, Sec 3, [8] are applicable.

8.7 Cathodic protection of tanks
8.7.1 Requirements of NR467 Steel Ships, Pt D, Ch 7, Sec 3, [9] are applicable.

8.8 Construction and testing
8.8.1 Requirements of NR467 Steel Ships, Pt D, Ch 7, Sec 3, [10] are applicable. In these requirements, references to NR467, Part B are to be replaced by the equivalent requirements defined in the present Rules.

9 Chemical tankers
9.1 Application
9.1.1 Ships having the service notation chemical tanker are to comply with the requirements of the present Article, taking into account the general requirements defined in NR467 Steel Ships, Pt D, Ch 8, Sec 1.

9.2 Location of cargo tanks
9.2.1 The location of cargo tank is to be in accordance with NR467 Steel Ships, Pt D, Ch 8, Sec 2, [3].

9.3 Ship arrangement
9.3.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 8, Sec 3.
NR 600, Ch 6, Sec 1

9.4 Cargo containment

9.4.1 General
Cargo containment including structure design principles, hull girder loads, hull scantlings, independent tank structures and supports are to be in accordance with requirements defined in NR467 Steel Ships, Pt D, Ch 8, Sec 4.

In these requirements, references to NR467, Part B are to be replaced by the equivalent requirements defined in the present Rules.

9.5 Other structures

9.5.1 Machinery space is to be in accordance with the requirements of NR467 Steel Ships, Pt D, Ch 8, Sec 4, [6].

9.6 Protection of hull metallic structure

9.6.1 Requirements of NR467 Steel Ships, Pt D, Ch 8, Sec 4, [7] are applicable.

9.7 Construction and testing

9.7.1 Requirements of NR467 Steel Ships, Pt D, Ch 8, Sec 4, [8] are applicable.

10 Tankers

10.1 Application

10.1.1 Ships having the service notation tanker are to comply with the requirements of the present Article.

10.1.2 As a rule, for ships having non homogeneous loading conditions, the hull scantlings are to be checked according to NR467 Steel Ships, Part B.

10.1.3 The liquid cargoes which are allowed to be carried by ships having the service notation tanker are specified in NR467 Steel Ships, Pt D, Ch 7, App 4.

10.2 Ship arrangement

10.2.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 10, Sec 2, [2].

10.3 Design loads

10.3.1 Application
In addition to the requirements of Chapter 3, the loading conditions, subdivided into departure and arrival conditions, defined in NR467 Steel Ships, Pt D, Ch 10, Sec 2, [5] are applicable.

10.4 Hull scantlings for steel structure

10.4.1 Plating
The thickness of the strength deck and bulkhead plating is to be not less than the values given in Tab 5.

<table>
<thead>
<tr>
<th>Plating</th>
<th>Minimum thickness, in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength deck</td>
<td>(5,5 + 0,02 L) k^{1/2} + 1,5</td>
</tr>
<tr>
<td>Tank bulkhead</td>
<td>L^{1/3} k^{1/6} + 4,5 s + 1</td>
</tr>
<tr>
<td>Watertight bulkhead</td>
<td>0,85 L^{1/3} k + 4,5 s + 1</td>
</tr>
</tbody>
</table>

Note 1: s : Length, in m, of the shorter side of the plate panel

10.4.2 Secondary stiffeners
The thickness of the web of secondary stiffeners is to be not less than the value obtained, in mm, from the following formula:

\[ t_{\text{MIN}} = 0,75 L^{1/3} k^{1/6} + 4,5 s + 2 \]

where s is the spacing, in m, of secondary stiffeners.

10.4.3 Primary stiffeners
The thickness of plating which forms the webs of primary supporting members is to be not less than the value obtained, in mm, from the following formula:

\[ t_{\text{MIN}} = 1,45 L^{1/3} k^{1/6} + 2 \]

10.4.4 Structure in way of the connection between independent tank and the hull structure
The tanks are to be locally strengthened in way of their connection to the hull structure and of their securing points, if any.

The structure of the ship is to be strengthened so as to avoid excessive deformations, due to the weight of the full tanks and inertia forces caused by motions of the ship, specified in Chapter 3.

10.4.5 Strength check with respect to stresses due to the temperature gradient
Direct calculations of stresses induced in the hull structures by the temperature gradient are to be performed for ships intended to carry cargoes at temperatures exceeding 90°C. In these calculations, the water temperature is to be assumed equal to 0°C.

The calculations are to be submitted to the Society for review.

10.5 Other structures

10.5.1 Machinery space is to be in accordance with the requirements of NR467 Steel Ships, Pt D, Ch 10, Sec 2, [7.1].

11 Passenger ships

11.1 Application

11.1.1 Ships having the service notation passenger ship are to comply with the requirements of the present Article, taking into account requirement defined in NR467 Steel Ships, Pt D, Ch 11, Sec 1, [1.1.3].
11.2 Ship arrangement

11.2.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 11, Sec 2.

11.3 Hull girder strength

11.3.1 Strength deck

The contribution to the longitudinal strength of the hull structures up to the strength deck is to be assessed on a case by case basis in the following cases:

- when the size of openings in the side shell and/or longitudinal bulkheads located below the deck assumed by the Designer as the strength deck decrease significantly the capability of the plating to transmit shear forces to the strength deck.
- when the ends of superstructures which are required to contribute to longitudinal strength may be considered not effectively connected to the hull structures in way.

11.4 Hull scantlings

11.4.1 Plating

As a rule, the thickness of the inner bottom, side and weather strength deck plating for steel structure is to be not less than the values given in Tab 6.

Table 6: Minimum plate thickness

<table>
<thead>
<tr>
<th>Plating</th>
<th>Minimum thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner bottom outside engine room</td>
<td>2,0+0,02Lk^{1/2}+4,5s</td>
</tr>
<tr>
<td>Side</td>
<td></td>
</tr>
<tr>
<td>• below freeboard deck</td>
<td>2,1+0,028Lk^{1/2}+4,5s</td>
</tr>
<tr>
<td>• between freeboard deck and strength deck</td>
<td></td>
</tr>
<tr>
<td>Weather deck and trunk deck</td>
<td>2,2k^{1/2}+2,1+s</td>
</tr>
<tr>
<td>Balconies</td>
<td>0,3+0,004Lk^{1/2}+4,5s</td>
</tr>
</tbody>
</table>

k, s : Material factor and length, in m, of the shorter side of the plate panel.

11.4.2 Side shell plating

If a complete deck does exist at a distance from the freeboard deck exceeding 2 times the standard height of superstructures as defined in Ch 1, Sec 1, [4.12.4], the side shell plating located between this complete deck and the strength deck may be taken not greater than the thickness of deckhouse sides defined in Ch 5, Sec 1.

12 Ro-ro passenger ships

12.1 Application

12.1.1 Ships having the service notation ro-ro passenger ship are to comply with the requirements of the present Article, taking into account the requirement defined in NR467 Steel Ships, Pt D, Ch 12, Sec 1, [1.1.3].

12.2 Ship arrangement

12.2.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 12, Sec 2, [12.4.2]

12.3 Structure design principles

12.3.1 Specific structure design principles are to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 12, Sec 3, [3].

12.3.2 When deemed necessary by the Society, the behaviour of the ship primary structural members under racking effect due to transverse forces induced by transverse accelerations is to be investigated by direct calculation on a case by case basis.

12.4 Design loads

12.4.1 General

Loads on deck and exposed deck specified in NR467 Steel Ships, Pt D, Ch 12, Sec 3, [4] are to be considered.

12.4.2 Lowest 0.5 m of bulkheads forming vertical division along escape route in accommodation

The pressures transmitted to the structures belonging to lowest 0.5 m of bulkheads and other partitions forming vertical divisions along escape routes are to be obtained, in kN/m², as specified in Ch 3, Sec 4, [4.2], where the value p₀ is to be taken not less than 1.5 kN/m² to allow them to be used as walking surfaces from the side of the escape route with the ship at large angles of heel.

12.5 Hull girder strength

12.5.1 Strength deck

The contribution to the longitudinal strength of the hull structures up to the strength deck is to be assessed on a case by case basis in the following cases:

- when the size of openings in the side shell and/or longitudinal bulkheads located below the deck assumed by the Designer as the strength deck decrease significantly the capability of the plating to transmit shear forces to the strength deck.
- when the ends of superstructures which are required to contribute to longitudinal strength may be considered not effectively connected to the hull structures in way.

12.6 Hull scantlings

12.6.1 Plating

a) Minimum thickness:

As a rule, the thickness of the inner bottom, side and weather strength deck plating for steel structure is to be not less than the values given in Tab 7
b) Lowest 0.5 m of bulkheads forming vertical division along escape route:

The thickness of plating belonging to the lowest 0.5 m of bulkheads and other partitions forming vertical divisions along escape routes is to be obtained according to Ch 4, Sec 3 where the loads are defined in [12.4.2].

c) Side shell:

If a complete deck does exist at a distance from the freeboard deck exceeding 2 times the standard height of superstructures as defined in Ch 1, Sec 1, the thickness of the side shell plating located between this complete deck and the strength deck may be taken not greater than the thickness of deckhouse sides defined in Ch 5, Sec 1.

Table 7 : Minimum plate thickness

<table>
<thead>
<tr>
<th>Plating</th>
<th>Minimum thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner bottom outside engine room</td>
<td>2.0 + 0.02Lk/2 + 4.5s</td>
</tr>
<tr>
<td>Side</td>
<td></td>
</tr>
<tr>
<td>• below freeboard deck</td>
<td>2.1 + 0.028Lk/2 + 4.5s</td>
</tr>
<tr>
<td>• between freeboard deck and strength deck</td>
<td></td>
</tr>
<tr>
<td>Weather deck and trunk deck</td>
<td>2.2k^1/2 + 2.1 + s</td>
</tr>
<tr>
<td>Balconies</td>
<td>0.3 + 0.004Lk/2 + 4.5s</td>
</tr>
</tbody>
</table>

k, s : Material factor and length, in m, of the shorter side of the plate panel

12.6.2 Stiffeners

The scantling of secondary and primary stiffeners belonging to the lowest 0.5 m of bulkheads and other partitions forming vertical divisions along escape routes is to be obtained according to Ch 4, Sec 4 and Ch 4, Sec 5 where the loads are defined in [12.4.2].

12.6.3 Other structures

Requirements defined in NR467 Steel Ships, Pt D, Ch 12, Sec 3 [7] are applicable.

13 Ship for dredging activity

13.1 Application

13.1.1 General

Ships for dredging activity as defined in [13.1.2] are to comply with the requirements of the present Article, taking into account the general requirements defined in NR467 Steel Ships, Pt D, Ch 13, Sec 1.

13.1.2 Type of ship for dredging activity covered by the present Rules

a) The present Rules apply to ship for dredging activity within the following maximum length:

• up to 90 m for service notation dredger
• up to 65 m for service notations hopper dredger, hopper unit, split hopper dredger and split hopper unit

b) Ship group

The ship group “cargo ships” or “non-cargo ships” as defined in Ch 1, Sec 1, [2.1.2] is to be considered as a general rule as follow:

• ships with the service notation dredger may be considered as non-cargo ships
• ships with one of the service notations hopper dredger, hopper unit, split hopper dredger or split hopper unit may be considered as cargo ships.

13.2 Structure design principles

13.2.1 General

The general structure design principles are to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 13, Sec 2, [2.1].

13.2.2 Structure members in the area of the hopper well

a) General

Longitudinal and transverse ship structures in the area of the hopper well are to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 13, Sec 2, [2.2] and [2.3].

b) Hopper dredgers and hopper units floors

The scantling of floors of ships with open wells fitted with bottom doors is to be obtained from a direct calculation according to:

• Ch 4, Sec 5, [1.2] for two- or three-dimensional beam model, or
• Ch 4, Sec 5, [1.3] for finite element model taking into account the assumptions defined in NR467 Steel Ships, Pt D, Ch 13, App 1, [2].

The permissible local stresses for primary structure check are defined in Ch 2, Sec 3, [2.2.2].

c) Other primary elements of hopper dredger and hopper units

Strong beams at deck level, brackets for trunks and girders supporting the hydraulic cylinder in the hopper spaces are to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 13, App 1, [3] to NR467 Steel Ships, Pt D, Ch 13, App 1, [5].

13.2.3 Specific arrangements

Arrangements relating to suction pipes, chafing areas, reinforcements for grounding and bolted structure are to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 13, Sec 2, [2.4] to NR467 Steel Ships, Pt D, Ch 13, Sec 2, [2.7].

13.3 Design loads

13.3.1 General

Design loads are to be determined for the various load cases in the following two situations:

• navigation situation, considering the draught T and the navigation coefficient n defined in Ch 1, Sec 1, [3.1.1]
• dredging situation, considering the dredging draught T_0 and the navigation coefficient n_0 defined in Tab 8.
For dredgers made of bolted structure, the Society may require the hull girder loads calculated with the maximum length of the unit when mounted to be applied to each individual element.

### 13.3.2 Hull girder loads
Where the hull girder strength of the ship is examined in accordance with Ch 4, Sec 2, [1.1.3], the hull girder loads are to be considered as follows:

a) General
The still water loads are to be as defined in Ch 3, Sec 2, [4].
Calculation of the still water bending moment and shear force for any loading case corresponding to a special use of the ship may be required by the Society on a case-by-case basis. In particular, in the case of stationary dredgers, the curve of the still water bending moment, where the suction pipe is horizontal, is to be submitted to the Society for approval.

b) Still water load conditions for service notations hopper dredger, hopper unit, split hopper dredger or split hopper unit
In addition to item a), still water loads are to be calculated for the following loading conditions:

- homogeneous loading at maximum dredging draught if higher than the maximum service draught
- partial loading conditions
- any specified non-homogeneous loading condition, in particular where dredgers are fitted with several hopper spaces
- navigation conditions with hopper space(s) filled with water up to the load line
- working conditions at international freeboard with the hopper space(s) filled with spoil
- ballast navigation conditions, with empty hopper space(s), if applicable.

c) Wave loads
The wave loads are to be as defined in Ch 3, Sec 2, [5].

### 13.3.3 Hull girder loads for dredgers of more than 65 m
The hull girder strength of the ship is to be examined taking into account the following hull girder loads:

a) Still water load conditions
As a rule, the vertical still water bending moments in dredging situation in hogging and sagging conditions are to be defined by the designer and are to be combined to the vertical wave bending moment defined in item b).

b) Vertical wave bending moments and shear forces
- In addition to the vertical wave bending moments $M_{W,V}$ and $M_{W,H}$ in navigation situation defined in Ch 3, Sec 2, the vertical wave bending moments in dredging situation at any hull transverse section are to be obtained, in kN m, from the following formulae:
  
  \[ M_{W,V,D} = -110 n_0 C L^2 B (C_B + 0.7) 10^{-3} \]
  
  where:
  
  $n_0$ : Coefficient defined in Tab 8 depending on the operating area, without being taken greater than the coefficient $n$ defined in Ch 1, Sec 1, [3.1.1].

- In addition to the vertical wave shear force $Q_{W,D}$ in navigation situation defined in Ch 3, Sec 2, the vertical wave shear force in dredging situation at any hull transverse section is to be obtained, in kN, from the following formula:
  
  \[ Q_{W,D} = 30 n_0 C L B (C_B + 0.7) 10^{-2} \]
  
  The values of bending moments and shear forces are to be applied along the ship from 0.30 $L$ to 0.75 $L$. When deemed necessary by the Society, a distribution of the bending moments and shear forces as defined in NR467 Steel Ships, Ch 5, Sec 2, [3] may be considered.

<table>
<thead>
<tr>
<th>Operating area</th>
<th>$n_0$</th>
<th>Associated $H_s$ in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>dredging within 8 miles from shore</td>
<td>1/3</td>
<td>$H_s &lt; 1.5$</td>
</tr>
<tr>
<td>dredging within 15 miles from shore</td>
<td>2/3</td>
<td>$1.5 \leq H_s &lt; 2.5$</td>
</tr>
<tr>
<td>or within 20 miles from port</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dredging over 15 miles from shore</td>
<td>1</td>
<td>$H_s \geq 2.5$</td>
</tr>
</tbody>
</table>

Note 1:
$H_s$ : Maximum significant wave height, in m, for operating area in dredging situation, according to the operating area notation assigned to the ship (see NR467 Steel Ships, Pt A, Ch 1, Sec 2 [4.6]).

### 13.3.4 Internal pressure for hopper well in dredging conditions
The internal pressure to be taken into account for hopper well, in kN/m², is to be not less than the greater value of the following formulæ:

\[ P = \delta_0 d_0 (g \cdot \frac{\sqrt{\alpha^2 + n_0^2}}{\alpha} + n_0^2) \geq 22 \]

\[ P = \delta_0 d_0 (10 + 4.5 n_0) \geq 22 \]

where:
\[ \delta_0 : \text{Coefficient equal to:} \]
\[ \delta_0 = \delta \quad \text{for } \delta < 1.4 \]
\[ \delta_1 = \delta + (1.4 - \delta) \sin^2 \alpha \quad \text{for } \delta \geq 1.4 \]
\[ d_0 : \text{Vertical distance, in m, from the calculation point to the highest weir level with the corresponding specific gravity of the mixture of sea water and spoil} \]
\[ \alpha : \text{Angle, in degrees, between the horizontal plane and the surface of the hull structure to which the calculation point belongs} \]
\[ a_z : \text{Vertical acceleration in dredging condition, in } \text{m/s}^2, \text{defined in Ch 3, Sec 4, [2.2.1]} \]
\[ n_0 : \text{Coefficient defined in Tab 8.} \]
13.4 Hull scantlings

13.4.1 Hull girder strength for dredger, hopper dredger and hopper unit

a) General

The hull girder strength of ships is to be checked according to Ch 4, Sec 1, [2.2] and Ch 4, Sec 2, taking into account the load conditions defined in [13.3.2].

For dredger of more than 65 m in length, the hull girder strength is to be checked taking into account the still water load conditions and the vertical wave bending moments defined in [13.3.3].

b) Calculation details

In the determination of the midship section modulus according to Ch 4, Sec 2, [3] or Ch 4, Sec 2, [4], as applicable, account is to be taken of both 85% and 100% effectiveness of the sectional area of the cellular keel.

However the 85% and 100% effectiveness of the sectional area of the cellular keel may be replaced by the actual effectiveness of the cellular keel determined by a three-dimensional finite element analysis.

Where cut-outs in the side shell are needed to fit the suction pipe guides, a section modulus calculation not taking account of the side shell plating may be required by the Society on a case-by-case basis, if the structural continuity is not fully achieved.

13.4.2 Hull girder strength for split hopper dredgers and split hopper units

The hull girder strength of split hopper dredgers and split hopper units is to be checked according to Ch 4, Sec 1, [2.2] and Ch 4, Sec 2, taking into account:

• the load conditions defined in [13.3.2], item b)
• the section modulus of the transverse section as defined in Ch 4, Sec 2, [3.2] considering the both half-hulls connected.

13.4.3 Hull scantlings

a) General

Hull scantlings are to be checked according to the applicable requirements of Ch 4, Sec 3 to Ch 4, Sec 5 for the following two situations:

• navigation situation, considering the draught T and the navigation coefficient n defined in Ch 1, Sec 1, [3.1.1]
• dredging situation, considering the dredging draught T0 and the navigation coefficient nD defined in Tab 8.

b) Minimum thicknesses

The thickness of plating is to be not less than the greater of the following values:

• 6 mm
• thickness obtained from Tab 9.

When no protection is fitted on the deck areas where heavy items of dredging equipment may be stored for maintenance, the thickness of the deck plating is to be not less than the value obtained, in mm, from the following formula:

\[ t = 6,1 + 0,040 L \frac{k}{2} + 4,5 \text{s} \]

c) Bottom plating

Where the bottom is longitudinally framed and the bilge is made of a transversely framed sloped plate, the bottom is to be assumed as being transversely framed when calculating the plating thickness.

The thickness of the bottom strake, to which the longitudinal bulkheads of the hopper space are connected, is to be not less than bottom plating thickness increased by 15%.

Table 9 : Minimum thickness of plating

<table>
<thead>
<tr>
<th>Plating</th>
<th>Minimum net thickness, in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keel</td>
<td>6,1 + 0,040 L \frac{k}{2} + 4,5 s</td>
</tr>
<tr>
<td>Bottom</td>
<td></td>
</tr>
<tr>
<td>• transverse framing</td>
<td>5,3 + 0,036 L \frac{k}{2} + 4,5 s</td>
</tr>
<tr>
<td>• longitudinal framing</td>
<td>4,4 + 0,036 L \frac{k}{2} + 4,5 s</td>
</tr>
<tr>
<td>Inner bottom outside hopper spaces</td>
<td>3,0 + 0,025 L \frac{k}{2} + 4,5 s</td>
</tr>
<tr>
<td>Side</td>
<td></td>
</tr>
<tr>
<td>• below freeboard deck</td>
<td>3,5 + 0,031 L \frac{k}{2} + 4,5 s</td>
</tr>
<tr>
<td>• between freeboard deck and strength deck</td>
<td>3,5 + 0,013 L \frac{k}{2} + 4,5 s</td>
</tr>
<tr>
<td>Strength deck within 0,4L amidships</td>
<td></td>
</tr>
<tr>
<td>• transverse framing</td>
<td>3,5 + 0,040 L \frac{k}{2} + 4,5 s</td>
</tr>
<tr>
<td>• longitudinal framing</td>
<td>3,5 + 0,032 L \frac{k}{2} + 4,5 s</td>
</tr>
<tr>
<td>Hopper well</td>
<td></td>
</tr>
<tr>
<td>• transverse and longitudinal bulkheads</td>
<td>3,7 + 0,034 L \frac{k}{2} + 4,5 s</td>
</tr>
<tr>
<td>• cellular keel plating</td>
<td>3,7 + 0,034 L \frac{k}{2} + 4,5 s</td>
</tr>
</tbody>
</table>

13.4.4 Specific hull scantlings

a) Well bulkheads and cellular keel platings

The thickness of hopper well bulkhead plating and cellular keel plating is to be not less than the thickness defined in Ch 4, Sec 3, considering the internal pressure defined in [13.3.4].

The thickness of the longitudinal bulkhead above the deck or within 0,1 D below the deck is to be not less than the thickness of the strength deck in way of the hatchways.

The thickness of the transverse and longitudinal bulkhead of a dredge pipe well is to be determined as for the side shell thickness.

b) Transversely framed bottoms

The scantlings of floors located inside large compartments, such as pump rooms, are to be obtained from a direct calculation, according to Ch 4, Sec 5, [1.2.2], and taking into account the following assumptions:

• floors are simply supported at ends
• local discontinuities in strength, due to the presence of wells, are to be considered.
c) Specific element scantling for split hopper unit

Superstructure hinges, deck hinges, hydraulic jack connections and chocks and hydraulic jacks and associated piping systems are to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 13, Sec 2, [8] to NR467 Steel Ships, Pt D, Ch 13, Sec 2, [10].

13.5 Rudders

13.5.1 General

The rudder stock diameter obtained from Ch 5, Sec 2, [9] is to be increased by 5%.

13.5.2 Rudders for split hopper dredgers and split hopper units

Each half-hull of ships with one of the service notations split hopper unit or split hopper dredger is to be fitted with a rudder complying with the requirements of Ch 5, Sec 2, [9].

An automatic system for synchronising the movement of both rudders is to be fitted.

13.6 Equipment

13.6.1 General

The equipment in anchors and chains is to be as defined in NR467 Steel Ships, Pt D, Ch 13, Sec 2, [12].

14 Non-propelled units

14.1 Application

14.1.1 Non-propelled ships having the service notation barge, pontoon or pontoon-crane are to comply with the requirements of the present Article.

14.1.2 General requirements defined in NR467 Steel Ships, Pt D, Ch 14, Sec 2, [1] are applicable.

14.2 Structure design principles

14.2.1 Specific structure design principles defined in NR467 Steel Ships, Pt D, Ch 14, Sec 2, [3] are applicable.

14.3 Hull girder strength

14.3.1 Non-propelled units lifted by crane

For non-propelled units intended to be lifted on board ship by crane, the hull girder strength is to be checked, in the condition of fully-loaded barge lifted by crane, through criteria defined in Ch 2, Sec 3, [2.1.1], multiplied by the following coefficient:

- 0.85 for stresses
- 1.15 for buckling safety coefficient.

### Table 10: Minimum thickness of plating

<table>
<thead>
<tr>
<th>Plating</th>
<th>Minimum thickness, in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decks, sides, bottom, inner bottom, bulkheads, primary supporting members in the cargo area</td>
<td></td>
</tr>
<tr>
<td>• for $L \leq 45$ m:</td>
<td>$(4,1 + 0,060 L) k^{0.5} + 1$</td>
</tr>
<tr>
<td>• for $L &gt; 45$ m:</td>
<td>$(5,9 + 0,023 L) k^{0.5} + 1$</td>
</tr>
<tr>
<td>Weather deck, within cargo area outside 0.4 L amidships</td>
<td>$11.3 \times k^{0.5} + 1$</td>
</tr>
<tr>
<td>Web of secondary stiffeners and other structures of cargo tanks</td>
<td></td>
</tr>
<tr>
<td>• for $L \leq 45$ m:</td>
<td>$(4,1 + 0,060 L) k^{0.5} + 1$</td>
</tr>
<tr>
<td>• for $L &gt; 45$ m:</td>
<td>$(5,9 + 0,023 L) k^{0.5} + 1$</td>
</tr>
</tbody>
</table>

**Note 1:**

$s$ : Length, in m, of the shorter side of the plate panel

14.3.2 Ships with service notation pontoon carrying special cargoes

For ships with the service notation pontoon intended for the carriage of special cargoes, such as parts of offshore units, the hull girder strength is to be checked through criteria to be agreed with the Society on a case-by-case basis.

Moreover, where these ships are fitted with arrangements for launching the above structures, additional calculations are to be carried out in order to evaluate the stresses during the various stages of launching. The Society may accept stresses higher than those defined in [14.3.1], to be considered on a case-by-case basis, taking into account favourable sea and weather conditions during launching.

14.4 Hull scantlings

14.4.1 General for steel structure

a) **Minimum thickness of ships with service notation barge carrying liquids**

For ships with the service notation barge carrying liquid cargo inside tanks, the thicknesses of cargo tank platings are to be not less than the values given in Tab 10.

For other structures or transverse bulkheads not forming boundaries of cargo tanks, the above minimum thicknesses may be reduced by 1 mm.

In pump rooms, the thicknesses of plating of exposed decks, longitudinal bulkheads and associated secondary stiffeners and primary supporting members are to be not less than the values given in Tab 10.

b) **Minimum thicknesses of decks forming tank top**

Where the decks of non-propelled units form a tank top, the minimum thicknesses of plating are to be not less than those obtained from Tab 10.

c) **Thickness of strength deck plating**

Within the cargo area, the thickness of strength deck plating is to be increased by 1.5 mm with respect to that calculated according to Ch 4, Sec 3.

14.4.2 Scantling of deck secondary stiffeners subjected to maximum allowable loads defined by the Designer

For longitudinal secondary deck stiffeners contributing to the global strength and subjected to maximum allowable deck loads defined by the Designer, the section modulus $Z$, in cm$^3$, and the shear area $A_{sh}$, in cm$^2$, may be taken not less than the values defined in Ch 4, App 2, [3], taking into account a permissible local scantling stress $\sigma_{ad}$, in N/mm$^2$, equal to:

$$\sigma_{ad} = 0.95R_y - 0.72\sigma_A$$

where:

$R_y, \sigma_A$ : Defined in Ch 4, App 2.

14.4.3 Hull scantlings of non-propelled units with the service notation pontoon fitted with arrangements and systems for launching operations

a) Additional information

In addition to the documentation specified in Ch 1, Sec 1, [7], the following information is to be submitted to the Society:

- maximum draught of the ship during the different stages of the launching operations
- operating loads and their distribution
- launching cradle location.

b) Scantlings of plating, secondary and primary stiffeners

In applying the formulae in Chapter 4, $T$ is to be taken equal to the maximum draught during the different stages of launching and taking into account, where appropriate, the differential static pressure.

c) Deck scantlings

The scantlings of decks are to be in accordance with Chapter 4, considering the maximum loads acting on the launching cradle.

The thickness of deck plating in way of launch ground ways is to be suitably increased if the cradle may be placed in different positions.

The scantlings of decks in way of pivoting and end areas of the cradle are to be obtained through direct calculations.

d) Launching cradles

The launching cradles are to be adequately connected to deck structures and arranged, as far as possible, in way of longitudinal bulkheads or at least of girders.

14.4.4 Hull scantlings of non-propelled units with service notation pontoon-crane

Requirements defined in NR467 Steel Ships, Pt D, Ch 14, Sec 2, [5.3] are applicable.

14.5 Hull outfitting

14.5.1 Equipment

a) Manned non-propelled units

The equipment of anchors, chain cables and ropes to be fitted on board manned non-propelled units is to comply with Ch 5, Sec 4.

Chain cables for anchors may be replaced by steel ropes having the same breaking load. The ropes are to be connected to the anchors by approximately 10 m of chain cable complying with Ch 5, Sec 4.

Non-propelled units continuously assisted by a tug may have only one anchor, complying with Ch 5, Sec 4, and a chain rope having length neither less than 75% of the length obtained according to Ch 5, Sec 4, nor less than 220 m.

b) Unmanned non-propelled units

For unmanned non-propelled units, the equipment is not required for classification purposes. The scantlings of anchors, chain cables and ropes to be fitted on board are the responsibility of the Designer.

c) Towing arrangements

Non-propelled units are to be fitted with suitable arrangements for towing, with scantlings under the responsibility of the Designer.

The Society may, at the specific request of the interested parties, check the above arrangements and the associated hull strengthening; to this end, the maximum pull for which the arrangements are to be checked is to be specified on the plans and documents submitted for approval.

15 Fishing vessels

15.1 Application

15.1.1 Ships having the service notation fishing vessel are to comply with the requirements of the present Article.

15.2 Ship arrangement

15.2.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 15, Sec 2.

For vessels less than 45 m in length, the collision bulkhead is to be located at a distance from the forward perpendicular $FPL_L$ of not less than 5% of the length $L_{LL}$ of the ship and not more than 5% of the length $L_{LL} + 1.35$ m. For ships greater than 24 m in length, this distance is not to be less than 2 m.

15.3 Specific design loads

15.3.1 General

The specific design loads defined in the present Article are to be taken into account in addition to the design loads defined in Chapter 3.

15.3.2 Fish hold

The design pressure $p_r$, in kN/m$^2$, to be considered for the scantling of fish holds, is to be obtained from the following formula:

$$p_r = \frac{Z_{TOP} - Z}{Z_{TOP} - Z_0} h_{TD}$$

where:
z\text{TOP} & : & Z \text{ co-ordinate of the highest point of the fish hold, in m} \\
z_0 & : & Z \text{ co-ordinate of the lowest point of the fish hold, in m} \\
z & : & Z \text{ co-ordinate of the calculation point, in m} \\
h_{TD} & : & \text{‘Tweendeck height, in m.} \\

In all cases, this pressure is to be taken not less than 10 kN/m\(^2\).

### 15.3.3 Cargo weather deck

The design pressure \(p_{WD}\), in kN/m\(^2\), to be considered for the scantling of cargo weather decks is to be obtained from the following formula:

\[
p_{WD} = 0.4 \ p_0 + 12 \ p_C
\]

where:

\(p_C\) & : & \text{Cargo load, in t/m\(^2\), defined by the Designer and to be taken, as a rule, not less than 10 kN/m\(^2\)} \\
\(p_0\) & : & \text{Sea pressure defined in Tab 11 with} \ \bar{P}_0 \text{ equal to:}
\begin{itemize}
  \item \(P_0 = 10 \text{ if } L \leq 50 \text{ m}\)
  \item \(P_0 = 0.2 \text{ L if } L > 50 \text{ m.}\)
\end{itemize}

### Table 11: Weather decks sea pressure

<table>
<thead>
<tr>
<th>Weather deck</th>
<th>Midship region</th>
<th>End regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength deck of single deck ship</td>
<td>(p_0 = p_0)</td>
<td>(p_0 = 1.5 \ p_0)</td>
</tr>
<tr>
<td>Multideck ships:</td>
<td>(p_0 = p_0)</td>
<td>(p_0 = 1.5 \ p_0)</td>
</tr>
<tr>
<td>- freeboard deck</td>
<td>(p_0 = 0.7 \ p_0)</td>
<td>(p_0 = 1.05 \ p_0)</td>
</tr>
<tr>
<td>- strength deck</td>
<td>(p_0 = p_0)</td>
<td>(p_0 = 0.6 \ p_0)</td>
</tr>
<tr>
<td>Forecastle deck</td>
<td>(p_0 = 0.6 \ p_0)</td>
<td>(p_0 = 0.6 \ p_0)</td>
</tr>
<tr>
<td>Poop deck</td>
<td>(p_0 = p_0)</td>
<td>(p_0 = 0.6 \ p_0)</td>
</tr>
<tr>
<td>Long superstructures</td>
<td>(p_0 = 0.4 \ p_0)</td>
<td>(p_0 = 0.4 \ p_0)</td>
</tr>
<tr>
<td>Short superstructures</td>
<td>(p_0 = 0.3 \ p_0)</td>
<td>(p_0 = 0.3 \ p_0)</td>
</tr>
<tr>
<td>First deck of deckhouses</td>
<td>(p_0 = 3.0 \ p_0)</td>
<td>(p_0 = 3.0 \ p_0)</td>
</tr>
<tr>
<td>Second deck of deckhouses</td>
<td>(p_0 = 3.0 \ p_0)</td>
<td>(p_0 = 3.0 \ p_0)</td>
</tr>
</tbody>
</table>

### 15.3.4 Lower deck

The design pressure \(p_{LD}\), in kN/m\(^2\), to be considered for the scantling of lower decks is to be obtained from the following formulae:

- for working deck:
  \[
p_{LD} = 8.5
\]
- for cargo ‘tweendeck:
  \[
p_{LD} = 7 \ h_{TD}\text{, to be taken not less than 10 kN/m}^2
\]

where:

\(h_{TD}\) & : & \text{‘Tweendeck height, in m.}

### 15.3.5 Dry uniform cargoes on decks

The design pressure transmitted to the deck structures is in general defined by the Designer and is to be taken, as a rule, not less than 10 kN/m\(^2\).

When the design pressure is not defined by the designer, it may be taken, in kN/m\(^2\), equal to \(7h_{TD}\).

### 15.4 Hull scantlings

#### 15.4.1 Bottom, side and decks plating

The thickness of bottom, side and decks plating is to be increased by 0.5 mm with respect to that calculated according to Chapter 4.

#### 15.4.2 Bottom structure for steel structure

The cross-sectional area, in cm\(^2\), of vertical solid bar keels made of forged or rolled, is to be not less than:

\[
S = (0.4 + 10 \ T/L) (1.5 \ L - 9) \text{ cm}^2
\]

The value of \(T/L\) is to be taken neither less than 0.050 nor more than 0.075.

The thickness, in mm, of solid bar keel is to be not less than:

\[
t = (5 + 0.7 \ L^{1/2}) \text{ mm}
\]

#### 15.4.3 Side structure in the engine room

As a rule, in the engine room of transversely framed ships, the section modulus of web frames is not to be less than four times that of adjacent frames and the web height is not to be less than twice that of adjacent frames.

#### 15.4.4 Deck structure

- a) Deck plating in way of masts and fishing devices
  In way of masts and fishing devices, the deck thickness in the reinforcement area is to be increased by 25% with respect to that obtained from the present Rules.

- b) Deck plating protected by wood sheathing or deck composition
  The thickness of deck plating protected by wood sheathing, deck composition or other arrangements deemed suitable by the Society may be reduced by 10% with respect to that obtained from the present Rules.

#### 15.4.5 Fish hold bulkheads

The fish hold bulkheads are to be checked according to Chapter 4, taking into account the pressure defined in [15.3.2].
15.4.6 Aft ramp

As a rule, the thickness of the aft ramp are defined as follow:

a) Plating of the aft ramp and the lower part of the aft ramp side:

   The thickness of plating of the aft ramp and the lower part of the aft ramp side is to be increased by 2 mm with respect to that calculated according to the present Rules for side plating with the same plate panel dimensions.

   As a rule, the thickness of plating of the aft ramp and the lower part of the aft ramp side is to be not less than 12 mm.

b) Plating of the upper part of the aft ramp side

   The thickness of plating of the upper part of the aft ramp side is to be not less than the value calculated according to the present Rules for side plating with the same plate panel dimensions.

15.5 Machinery casings

15.5.1 Arrangements

As a rule, ordinary stiffeners are to be located:

- at each frame, in longitudinal bulkheads
- at a distance of about 750 mm, in transverse bulkheads.

The ordinary stiffener spacing in portions of casings which are particularly exposed to wave action is considered by the Society on a case by case basis.

15.5.2 Engine room skylight coamings

a) Ships greater than 65 m in length:

   Engine room skylight are to be in accordance with NR467 Steel Ships, Pt B, Ch 8, [7.2].

b) Ships less than 65 m in length:

   If the engine room where skylights are fitted with opening-type covers providing light and air, the height of coamings is to be not less than:

   - 900 mm, for skylights located on working decks
   - 300 mm, for skylights located on superstructure decks.

The thickness of engine room skylight coamings is to be not less than 6 mm.

Where the height of engine room skylight coamings is greater than 900 mm, the section modulus of vertical ordinary stiffeners with spacing not greater than 760 mm is to be increased by 10% with respect to that obtained for vertical ordinary stiffeners of deckhouses.

15.5.3 Scantlings

The scantlings of plating and ordinary stiffeners are to be not less than those of plating and ordinary stiffeners of superstructures and deckhouses. In any case, the thickness of protected or unprotected casing bulkheads is to be not less than 5 mm.

15.6 Arrangement for hull and superstructure openings

15.6.1 General

Requirements defined in the present Article are applicable to ships less than 65 m in length.

The arrangement for hull and superstructure openings of ships greater than 65 m in length are to be in accordance with NR467 Steel Ships.

15.6.2 Sidescuttles

Sidescuttles may not be fitted in such a position that their sills are below a line drawn parallel to the sheer at side and having its lowest point 0.5 m above the summer load water-line.

No sidescuttles may be fitted in any spaces which are appropriated exclusively for the carriage of cargo.

15.6.3 Freeing ports

The freeing port area in bulwarks is to be not less than the value obtained from the formulae in NR467 Steel Ships, Pt B, Ch 8, Sec 10, [6].

For ships with \( L < 24 \) m and the navigation notation coastal area, the freeing port area in bulwarks on each side of the ship may be not less than the value obtained from the following formula:

\[
A = 0.035 \ell_b + A_c
\]

where:

- \( \ell_b \): Length, in m, of bulwark in the well, to be taken not greater than 0.7 \( L \)
- \( A_c \): Area, in \( m^2 \), to be taken, with its sign, equal to:

  \[
  A_c = \begin{cases} 
  0.04 \ell_b (h_b - 1.2) & \text{for } h_b > 1.2 \\
  0 & \text{for } 0.9 \leq h_b \leq 1.2 \\
  0.04 \ell_b (h_b - 0.9) & \text{for } h_b < 0.9
  \end{cases}
  \]

- \( h_b \): Mean height, in m, of bulwark in the well of length \( \ell_b \).

15.6.4 Openings in bulkheads of enclosed superstructures and other outer structures

All access openings in bulkheads of enclosed superstructures and other outer structures (e.g. machinery casings) through which water can enter and endanger the ship are to be fitted with doors of steel or other equivalent material, permanently and strongly attached to the bulkhead, and framed, stiffened and fitted so that the whole structure is of equivalent strength to the unpierced bulkhead and weather-tight when closed. The doors are to be capable of being operated from both sides and generally to open outwards to give additional protection against wave impact.

These doors are to be fitted with gaskets and clamping devices or other equivalent means permanently attached to the bulkhead or to the door themselves.

Other openings are to be fitted with equivalent covers, permanently attached in their proper position.
15.6.5 Doors sills

The height of the sill of the doors is to be not less than:

- 600 mm above the working deck
- 300 mm above the deck of the lower tier of superstructures.

For doors protected from the direct impact of waves, except for those giving direct access to machinery spaces, the height of the sill may be taken not less than:

- 380 mm above the working deck
- 150 mm above the deck of the lower tier of superstructures.

15.6.6 Ventilator coamings

The height of ventilator coamings is to be not less than the value obtained from Tab 12.

The thickness of ventilator coaming plating is to be not less than both the thickness obtained for the ship’s deck and the thickness obtained for a deckhouse in the same position as the ventilator.

Ventilator coamings are to be provided with weathertight closing appliances to be used in rough weather. These appliances may be omitted when the ventilator height is greater than the minimum value specified in Tab 12.

15.7 Lifting appliances and fishing devices

15.7.1 General

The fixed parts of lifting appliances and fishing devices, considered as an integral part of the hull, are the structures permanently connected by welding 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.

15.7.2 Design loads

The design loads to be considered for the strength check of masts, fishing devices and reinforcements under decks are:

- the weights of booms and net hauling fittings
- the cargo loads, to be taken equal to the maximum traction loads of the different lifting appliances, considering the rolling-up diameters defined hereafter.

The rolling-up diameters to be taken for the maximum traction loads of the lifting appliances are for:

- the fishing winches: the mid rolling-up diameter
- the net winches: the maximum rolling-up diameter
- the winding-tackles: the minimum rolling-up diameter.

15.7.3 Strength check

The structure check of the reinforcements under decks supporting fishing devices, and to the strength check of fishing devices and masts if welded to the deck is to be carried out by direct calculation.

Structural elements of masts, fishing devices and local reinforcements under decks are to be checked by direct calculations, taking into account the following permissible stresses:

a) for steel and aluminium structure:

\[
\sigma_{VM} \leq 0,5 R
\]

where:

\[
\sigma_{VM} : \text{Von Mises equivalent stress, in N/mm}^2, \text{to be obtained as a result of direct calculations}
\]

\[
R : \text{Minimum yield stress for scantling criteria, in N/mm}^2, \text{of the material, defined in Ch 1, Sec 2.}
\]

b) for composite structure:

\[
SF_{id} = 1,4 SF
\]

\[
SF_{id} = 1,4 SF_{CS}
\]

where:

\[
SF : \text{Rules safety coefficient applicable to maximum stress defined in Ch 2, Sec 3, [3.2.3]}
\]

\[
SF_{CS} : \text{Rules safety coefficient applicable to combined stress defined in Ch 2, Sec 3, [3.2.3].}
\]

The buckling strength of the structural elements of masts and fishing devices is to be checked in compliance with Chapter 4.

15.8 Hull outfitting

15.8.1 Rudder stock scantlings

The rudder stock diameter is to be increased by 5% with respect to that obtained from the formula in Ch 5, Sec 2, [9].

Table 12 : Ventilator coamings

<table>
<thead>
<tr>
<th>Ship’s length, in m</th>
<th>Coaming height, in mm</th>
<th>Minimum height of ventilators, in m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ventilator openings on working decks</td>
<td>Ventilator openings on decks of lower tier of superstructure</td>
</tr>
<tr>
<td>L &gt; 45</td>
<td>900</td>
<td>760</td>
</tr>
<tr>
<td>24 ≤ L ≤ 45</td>
<td>760</td>
<td>450</td>
</tr>
<tr>
<td>12 ≤ L &lt; 24</td>
<td>760</td>
<td>450</td>
</tr>
<tr>
<td>L &lt; 12</td>
<td>300</td>
<td>300</td>
</tr>
</tbody>
</table>
15.8.2 Propeller shaft brackets
Propeller shaft brackets are to be in accordance with Ch 5, Sec 2, [12].
For ships less than 30 m in length, single arm propeller shaft brackets may be fitted.

15.8.3 Equipment
The equipment in chain and anchor for ships having the service notation fishing vessel is defined in Ch 5, Sec 4.
Equipment in anchors and cables defined in Ch 5, Sec 4 may be reduced on a case-by-case basis. Nevertheless, it belongs to the Designer and/or shipyard to submit all the relevant information demonstrating that reduced equipment - its configuration - and all its components, fully copes with the anchoring forces most frequently encountered during service.

For ships of special design or for ships engaged in special services or on special voyage, the Society may consider anchoring equipment other than defined in the present Article and in Ch 5, Sec 4.

As an alternative to the stud link chain cables calculated in Ch 5, Sec 4, [3.2], wire ropes may be used in the following cases:

- wire ropes for both the anchors, for ship’s length less than 30 m
- wire rope for one of the two anchors, for ship’s length between 30 m and 40 m.

The wire ropes above are to have a total length equal to 1.5 times the corresponding required length of stud link chain cables, obtained from Ch 5, Sec 4, [3.2], and a minimum breaking load equal to that given for the corresponding stud link chain.

A short length of chain cable is to be fitted between the wire rope and the anchor, having a length equal to 12.5 m or the distance from the anchor in the stowed position to the winch, whichever is the lesser.

When chain cables are replaced by trawl warps, the anchor is to be positioned on the forecastle deck so that it may be readily cast after it has been shackled to the trawl warp. Chocks or rollers are to be fitted at suitable locations, along the path of the trawl warps, between the winch and the mooring chocks.

15.9 Protection of hull metallic structure

15.9.1 Protection of decks by wood sheathing
Before fitting the wood sheathing, deck plating is to be protected with suitable protective coating.

The thickness of wood sheathing of decks is to be not less than:

- 65 mm, if made of pine
- 50 mm, if made of hardwood, such as teak.

The width of planks is not to exceed twice their thickness.

15.9.2 Protection of cargo sides by battens
In cargo spaces, where thermal insulation is fitted, battens formed by spaced planks are generally to be fitted longitudinally.

15.9.3 Deck composition
The deck composition is to be of such a material as to prevent corrosion as far as possible and is to be effectively secured to the steel structures underneath by means of suitable connections.

16 Offshore patrol vessel

16.1 General

16.1.1 Ships having the service notation OPV are to comply with the requirements defined in NR467 Steel Ships, Pt D, Ch 16, Sec 1.

17 Launch and seagoing launch

17.1 Application

17.1.1 Ships having the service notation launch or seagoing launch are to comply with the requirements of the present Article.

17.2 Hull outfitting

17.2.1 Equipment
For small ship, the provisions for mooring and anchoring defined in the present Rules may be reduced. The attention of Shipowners is drawn to the fact that additional equipment (length of anchor lines, type of anchor...) may be necessary to ensure anchoring in the conditions of service the most frequently encountered, taking into account the depth of water and the nature of the sea-bed.

17.2.2 The equipment in anchors and chains is defined in Ch 5, Sec 4.

17.2.3 On ships carrying two anchor chains of the prescribed length, the weight of the second anchor may be reduced by one third.

17.2.4 Anchoring gear comprising only 8 to 10 m of chain attached to each anchor, supplemented by hawsers of equivalent strength to the prescribed chain, may be accepted, subject to the agreement of the Shipowner and of the National Regulations of the country whose flag the ship carries.

If such anchoring gear, with cables and reduced chains, is adopted, the weight of the second anchor is to be equal to that of the first anchor as defined in Ch 5, Sec 4.

18 Tugs

18.1 Application

18.1.1 Ships having one of the service notations tug, salvage tug or escort tug are to comply with the requirements of the present Article.

The general scope of application of these service notations is defined in NR467 Steel Ships, Pt E, Ch 1, Sec 1.
18.2 Hull structure general requirements

18.2.1 Specific structure design principles and arrangements are to comply with the following Sub Article of NR467 Steel Ships, Pt E, Ch 1, Sec 3:
- typical design arrangements: [2.1]
- structure design principles: [2.2]
- other structure (machinery casings, emergency exits from machinery space and height of hatchway coamings): [2.4]
- rudder and bulwarks: [2.5].

18.3 Hull scantlings

18.3.1 General
The scantlings of plating, secondary stiffeners and primary stiffeners are to be in accordance with Chapter 4, where the hull girder loads and the local loads are defined in Chapter 3, to be calculated for a moulded draught T not less than 0,85 D.

18.4 Anchoring and mooring equipment

18.4.1 Anchoring equipment
The anchoring equipment is to be determined as defined in Ch 5, Sec 4.

18.4.2 Number of anchors
A reduction of the number of anchors and chain cables defined in Ch 5, Sec 4 may be accepted, based on redundancy according to NR467 Steel Ships, Pt E, Ch 1, Sec 3 [2.6.2].

18.4.3 Wire ropes
Wire ropes may be used as an alternative to chain cables as defined in NR467 Steel Ships, Pt E, Ch 1, Sec 3 [2.6.1].

18.5 Towing arrangements

18.5.1 The towing arrangements are to be in accordance with NR467 Steel Ships, Pt E, Ch 1, Sec 3 [2.7].

18.6 Additional requirements for escort tugs

18.6.1 The requirements of NR467 Steel Ships, Pt E, Ch 1, Sec 3 [3] are applicable ships having the service notation escort tug.

18.7 Additional requirements for salvage tug

18.7.1 The requirements of NR467 Steel Ships, Pt E, Ch 1, Sec 3 [4] are applicable ships having the service notation salvage tug.

18.8 Integrated tug/barge combination

18.8.1 Application
The requirements of this Sub-article apply to the integrated tug/barge combinations constituted by a tug having the additional service feature barge combined and barge having the additional service feature tug combined.

The tug/barge combination is to be examined on a case by case basis with the present Rules when the length of the tug/barge combination is less than 65 m.

Where the tug/barge combination length is greater than 65 m, the requirements of NR467 Steel Ships, Pt E, Ch 1, Sec 4 are applicable.

Two types of connections between tug and barge are to be considered as defined in NR467 Steel Ships, Pt E, Ch 1, Sec 4 [1].

18.8.2 Hull scantling
Hull scantling criteria of tug and barge are to be as defined in Chapter 4 and Chapter 5 considering successively the tug and the barge as an individual ship.

Where the tug/barge combination length is less than 65 m, the hull scantling is to be examined according to the present Rules considering the integrated tug/barge combination as a ship of the size of the combination for the calculation of the local loads and the hull girder loads.

For integrated tug/barge combinations with removable flexible connection, the effect on the degree of freedom of the connection on the still water hull girder loads in the combination may be taken into account (e.g. free pitch of the tug with respect to the barge implies vertical bending moment equal to zero in the connection).

The forces transmitted through the connection are to be defined by direct calculation.

18.8.3 Connection
Local reinforcement of the tug and the barge and connection scantling are to be as defined in NR467 Steel Ships, Pt E, Ch 1, Sec 4 [5].

18.8.4 Rudder
The tug rudder and steering gear are to be in accordance with the present Rules, considering the maximum service speed in ahead and astern condition of the tug as an individual ship and the maximum service speed in ahead and astern condition of the integrated tug/barge combination.

18.8.5 Test of the disconnection procedure of removable connection
Tests are to be carried out as defined in NR546 Steel Ships, Pt E, Ch 1, Sec 4 [8].

18.8.6 Equipment
The equipment is to be in accordance with the requirements in both
- Ch 5, Sec 4 for the tug, and
- [14.5.1] for the barge, considering the barge as a ship of the size of the integrated tug/barge combination.
NR 600, Ch 6, Sec 1

18.9 Testing

18.9.1 Requirements of NR467 Steel Ships, Pt E, Ch 1, Sec 5 are applicable.

19 Anchor handling vessels

19.1 Application

19.1.1 Ships having the service notations anchor handling are to comply with the requirements of the present Article, taking into account the general requirements defined in NR467 Steel Ships, Pt E, Ch 2, Sec 1.

19.1.2 Hull structure
Specific hull structures are to comply with the requirements defined in NR467 Steel Ships, Pt E, Ch 2, Sec 3.

19.2 Testing

19.2.1 Requirements of NR467 Steel Ships, Pt E, Ch 2, Sec 4 are applicable.

20 Supply vessels

20.1 Application

20.1.1 Ships having the service notation supply are to comply with the requirements of the present Article.

20.1.2 General
General requirements defined in NR467 Steel Ships, Pt E, Ch 3, Sec 1 are applicable.

20.2 Ship arrangement

20.2.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt E, Ch 3, Sec 2.

20.3 Structure design principles

20.3.1 Specific structure design principles are to comply with the requirements defined in NR467 Steel Ships, Pt E, Ch 3, Sec 4 [1].

20.4 Design loads

20.4.1 Dry uniform cargoes
The still water and inertial pressures transmitted to the structure of the upper deck intended to carry loads are to be obtained, in kN/m², as specified in Ch 3, Sec 4, [3.2.1], where the value of $p_s$ is to be taken not less than 24 kN/m².

20.5 Hull scantlings for steel structure

20.5.1 Plating
The thickness of the side and upper deck plating is to be not less than the values given in Tab 13.

### Table 13: Minimum plating thickness

<table>
<thead>
<tr>
<th>Plating</th>
<th>Minimum thickness, in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side below freeboard deck</td>
<td>The greater value obtained from:</td>
</tr>
<tr>
<td></td>
<td>$3.1 + 0.031 L^0.5 + 4.5 s$</td>
</tr>
<tr>
<td></td>
<td>$8 L^0.5 + 1$</td>
</tr>
<tr>
<td>Side between freeboard deck and strength deck</td>
<td>The greater value obtained from:</td>
</tr>
<tr>
<td></td>
<td>$3.1 + 0.013 L^0.5 + 4.5 s$</td>
</tr>
<tr>
<td></td>
<td>$8 L^0.5 + 1$</td>
</tr>
<tr>
<td>Upper deck</td>
<td>7</td>
</tr>
</tbody>
</table>

Within the cargo area, the thickness of strength deck plating is to be increased by 1.5 mm with respect to that determined according to Ch 4, Sec 3.

However, the above increase in thickness by 1.5mm may be omitted provided all the following conditions are fulfilled:

a) wooden planking provide an efficient protection of the deck at the satisfaction of the society
b) the welding of the steel fittings securing the wood protection is performed before coating application
c) full coating application is applied after item b) above.

20.5.2 Secondary stiffeners

a) Longitudinally framed side exposed to bumping

In the whole area where the side of the supply vessel is exposed to bumping, the section modulus of secondary stiffeners is to be increased by 15% with respect to that determined according to Ch 4, Sec 4.

b) Transversely framed side exposed to bumping

In the whole area where the side of the supply vessel is exposed to bumping, the section modulus of secondary stiffeners, i.e. side, ‘tweendeck and superstructure frames, is to be increased by 25% with respect to that determined according to Ch 4, Sec 4.

20.5.3 Primary stiffeners

In the whole area where the side of the supply vessel is exposed to bumping, a distribution stringer is to be fitted at mid-span, consisting of an intercostal web of the same height as the secondary stiffeners, with a continuous face plate.

The section modulus of the distribution stringer is to be at least twice that calculated in [20.5.2] for secondary stiffeners.

Side frames are to be fitted with brackets at ends.

Within reinforced areas, scallop welding for all side secondary stiffeners is forbidden.

20.6 Other structure

20.6.1 Aft part

Aft part structure is to be in accordance with NR467 Steel Ships, Pt E, Ch 3, Sec 4, [4.1].
20.6.2 Superstructures and deckhouses

a) Deckhouses and forecastle

Due to their location at the forward end of the supply vessel, deckhouses are to be reduced to essentials and special care is to be taken so that their scantlings and connections are sufficient to support wave loads.

The forecastle length not exceed 0.3 to 0.4 times the length L.

b) The thickness of forecastle aft end plating and of plating of deckhouses located on the forecastle deck for steel structure is to be not less than the values given in Tab 14.

c) Secondary stiffeners

The section modulus of secondary stiffeners of the forecastle aft end and of deckhouses located on the forecastle deck for steel structure is to be not less than the values obtained from Tab 15.

Secondary stiffeners of the front of deckhouses located on the forecastle deck are to be fitted with brackets at their ends. Those of side and aft end bulkheads of deckhouses located on the forecastle deck are to be welded to decks at their ends.

Table 14: Minimum thickness of forecastle and deckhouses located on the forecastle deck

<table>
<thead>
<tr>
<th>Structure</th>
<th>Plating</th>
<th>Minimum thickness, in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecastle</td>
<td>aft end</td>
<td>1.04 (5 + 0.01 L) + 0.5</td>
</tr>
<tr>
<td>Deckhouses</td>
<td>front</td>
<td>1.44 (4 + 0.01 L) + 0.5</td>
</tr>
<tr>
<td></td>
<td>sides</td>
<td>1.31 (4 + 0.01 L) + 0.5</td>
</tr>
<tr>
<td></td>
<td>aft end</td>
<td>1.22 (4 + 0.01 L) + 0.5</td>
</tr>
</tbody>
</table>

Table 15: Minimum section modulus of forecastle and deckhouse secondary stiffeners located on the forecastle deck

<table>
<thead>
<tr>
<th>Structure</th>
<th>Secondary stiffeners on</th>
<th>Section modulus, in cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecastle</td>
<td>aft end plating</td>
<td>3 times the value calculated according to Ch 5, Sec 1, [4]</td>
</tr>
<tr>
<td>Deckhouses</td>
<td>front plating</td>
<td>0.75 times the value for the forecastle 'tweenend frames</td>
</tr>
<tr>
<td></td>
<td>sides plating</td>
<td>0.75 times the value for the forecastle 'tweenend frames</td>
</tr>
<tr>
<td></td>
<td>aft end plating</td>
<td>0.75 times the value for the forecastle 'tweenend frames</td>
</tr>
</tbody>
</table>

20.6.3 Structure of cargo tanks

Scantling of cargo tanks is to be in compliance with the provisions of Chapter 3 and Chapter 4.

General arrangements defined in NR467 Steel Ships, Pt E, Ch 3, Sec 5, [3] to [6] are applicable.

20.7 Hull outfitting

20.7.1 Rudders

The rudder stock diameter is to be increased by 5% with respect to that determined according to Ch 5, Sec 2, [9].

20.7.2 Bulwarks

- General:
  High bulwark fitted with a face plate of large cross-sectional area which contributes to the longitudinal strength are to be examined on a case by case basis.
- Stays:
  The bulwark stays are to be designed with an attachment to the deck able to withstand an accidental shifting of deck cargo (e.g. pipes).

20.7.3 Chain locker

Chain lockers are to be arranged as gas-safe areas. Hull penetrations for chain cables and mooring lines are to be arranged outside the hazardous areas.

Note 1: Hazardous area is an area in which an explosive atmosphere is or may be expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

21 Fire-fighting ships

21.1 Application

21.1.1 Ships having the service notation fire-fighting are to comply with the requirements of the present Article.

21.1.2 Hull material

Hull and superstructure materials are to comply with the requirements defined in NR467 Steel Ships, Pt E, Ch 4, Sec 4, [2.1].

21.2 Structure design principles

21.2.1 Hull structure

The strengthening of the structure of the ships, where necessary to withstand the forces imposed by the fire-extinguishing systems when operating at their maximum capacity in all possible directions of use, are to be considered by the Society on a case-by-case basis.

21.2.2 Water and foam monitors

The seatings of the monitors are to be of adequate strength for all modes of operation.

21.2.3 Arrangement for hull and superstructure openings

On ships for which the additional service feature water spraying is not assigned, steel deadlights or external steel shutters are to be provided on all windows, sidescuttles and navigation lights, except for the windows of the navigation bridge.

22 Oil recovery ships

22.1 Application

22.1.1 Ships having the service notation oil recovery are to comply with the requirements of the present Article, taking into account general requirements defined in NR467 Steel Ships, Pt E, Ch 5, Sec 1.
22.2 Ship arrangement

22.2.1 Specific ship arrangement is to comply with the requirements defined in NR467 Steel Ships, Pt E, Ch 5, Sec 2, [1].

22.3 Hull scantlings

22.3.1 Additional loads
For the checking of structures supporting oil recovery equipment, the reactions induced by this equipment during oil recovery operations may be calculated assuming that the oil recovery operations take place in moderate sea conditions (accelerations reduced by 10%).

If lifting appliances are used during oil recovery operations, the scantling of their supporting structures is to be checked according to Ch 5, Sec 2, [14].

In case of oil collected in movable tanks fitted on the weather deck, the resulting reactions to be considered for deck scantling are to be calculated, as a rule, according to Ch 3, Sec 4.

22.4 Construction and testing

22.4.1 Testing
Tests are to be carried out according to a specification submitted by the interested Party, in order to check the proper operation of the oil recovery equipment.

These tests may be performed during dock and sea trials.

23 Cable-laying ships

23.1 Application

23.1.1 Ships having the service notation cable laying are to comply with the requirements of the present Article.

23.2 Hull scantlings

23.2.1 Cable tanks
The scantlings of cable tanks are to be obtained through direct calculations taking into account still water and wave loads for the most severe condition of use.

23.2.2 Connection of the machinery and equipment with the hull structure
The scantling of the structures in way of the connection between the hull structure and the machinery and equipment, constituting the laying or hauling line for submarine cables, are to be obtained through direct calculation based on the service loads of such machinery and equipment, as specified by the Designer.

The service loads of machinery and equipment specified by the Designer are to take into account the inertial loads induced by ship motions in the most severe condition of use.

23.3 Other structures

23.3.1 Fore part
In general, a high freeboard is needed in the forward area, where most repair work is carried out, in order to provide adequate safety and protection against sea waves.

23.4 Equipment

23.4.1 Hawse pipe
Hawse pipes are to be integrated into the hull structure in such a way that anchors do not interfere with the cable laying.

23.4.2 Sheaves
Where there is a risk that, in rough sea conditions, sheaves are subjected to wave impact loads, special solutions such as the provision of retractable type sheaves may be adopted.

24 Diving support vessels

24.1 Application

24.1.1 Ships intended to support diving operations are to comply with the requirements of the present Article.

24.1.2 General
General requirements defined in NR467 Steel Ships, Pt E, Ch 7, Sec 1 are applicable.

24.2 General arrangement

24.2.1 General arrangements defined in NR467 Steel Ships Pt E, Ch 7, Sec 2 are applicable.

24.2.2 Diving equipment foundations are to comply with NR467 Steel Ships, Pt E, Ch 7, Sec 3.

24.2.3 Launching system foundations are to comply with the requirements defined in Ch 5, Sec 2, [14] for lifting appliances.

24.2.4 Ships having the service notation diving support-capable are to comply with the requirements of NR467 Steel Ships, Pt E, Ch 7, Sec 6.

24.3 Initial inspection and testing

24.3.1 Requirements provided for initial inspection and testing of the diving equipment are defined in NR467 Steel Ships, Pt E, Ch 7, Sec 7.

25 Lifting units

25.1 Application

25.1.1 Ships having the service notation lifting are to comply with the requirements of the present Article.

25.1.2 General requirements defined in NR467 Steel Ships, Pt E, Ch 8, Sec 1 are applicable.
25.1.3 General arrangement
Location of lifting appliances and position of the crane during navigation are to be as defined in NR467 Steel Ships Pt E, Ch 8, Sec 2.

25.1.4 Structural assessment
The structural assessment of the foundations of the lifting equipment, the devices for stowage during transit and the connecting bolts between the lifting equipment and the foundation is to be carried out as defined in NR467 Steel Ships, Pt E, Ch 8, Sec 4.

25.2 Initial inspection and testing

25.2.1 Lifting installations
Initial inspection and testing of the lifting installations are defined in NR467 Steel Ships Pt E, Ch 8, Sec 6.

26 Semi-submersible cargo ships

26.1 Application
26.1.1 Ships having the service notation semi-submersible cargo ships are to comply with the requirements of the present Article, taking into account the general requirements defined in NR467 Steel Ships Pt E, Ch 9, Sec 1.

26.1.2 General arrangement
General arrangements defined in NR467 Steel Ships Pt E, Ch 9, Sec 2 are applicable.

26.1.3 Hull structure
Specific requirements for the structural assessment of semi-submersible cargo ships in temporary submerged conditions defined in NR467 Steel Ships Pt E, Ch 9, Sec 4 [1] to [5] are applicable.

The scantling of the hull structure and the connection with the buoyancy casings are to be checked according to NR467 Steel Ships Pt E, Ch 9, Sec 4 [6], taking into account the navigation coefficient n, defined in NR467 Steel Ships Pt E, Ch 9, Sec 4 for the calculation of the ship relative motion h, and wave loads defined in Ch 3, Sec 3, [2.2].

26.2 Initial inspection and testing
26.2.1 Initial inspection and testing of the submersion function of the ship are defined in NR467 Steel Ships Pt E, Ch 9, Sec 8.

27 Standby rescue vessels

27.1 General
27.1.1 Ships having the service notation standby rescue are to comply with the requirements of NR546 Steel Ships Pt E, Ch 10, Sec 1, Sec 2 and Sec 3.

28 Accommodation units

28.1 General
28.1.1 Ships having the service notation accommodation are to comply with requirements of NR546 Steel Ships Pt E, Ch 11 Sec 1.

29 Pipe-laying units

29.1 Application
29.1.1 Ships having the service notation pipe laying are to comply with the requirements of the present Article, taking into account the general requirements defined in NR467 Steel Ships Pt E, Ch 12, Sec 1.

29.2 Structural assessment
29.2.1 The structural assessment of the foundations of pipe laying equipment supported by the hull structure is to be carried out as defined in NR467 Steel Ships, Pt E, Ch 12, Sec 3.

29.3 Initial inspection and testing
29.3.1 Initial inspection and testing of the pipe laying installations are defined in NR467 Steel Ships Pt E, Ch 12, Sec 4.
Chapter 7

CONSTRUCTION AND TESTING

SECTION 1  GENERAL
SECTION 2  WELDING FOR STEEL
SECTION 3  TESTING
SECTION 4  CONSTRUCTION SURVEY
SECTION 1 GENERAL

1 General

1.1

1.1.1 The present Chapter contains the requirements concerning the welding, welds and assembling of structure, and the testing and construction survey.

2 Welding, welds and assembly of structure

2.1 Material

2.1.1 The scantling and joint design of welded connection for ships built in steel materials are defined in Sec 2.

2.1.2 The equivalent requirements for ships built in aluminium alloys are defined in NR561 Aluminium Ships.

The conditions for heterogeneous assembly between steel and aluminium structures are also to be as defined in NR561 Aluminium Ships.

2.1.3 The scantling of joint assembly for ships built in composite materials are to be as defined in NR546 Composite Ships.

3 Testing

3.1 General

3.1.1 The testing conditions for tanks, watertight and weathertight structures for ships built in steel, aluminium and composite materials are define in Sec 3.

4 Construction survey

4.1 General

4.1.1 The requirements for hull construction and survey within the scope of classification and/or certification of ships hulls are defined in:

- for steel ship: in Sec 4
- for aluminium ship: in the NR561 Aluminium Ships
- for composite ship: in the NR546 Composite Ships.
SECTION 2  WELDING FOR STEEL

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 ships built in steel materials.

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 Chapter 5 of NR216 Materials and Welding.

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 Sec 4, [3.4] is to be submitted to the Surveyor for examination.

2  Scantling of welds

2.1  Butt welds

2.1.1  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 welding may be used where fillet welding is not possible. Slot welding 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.

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 2). 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 welding

2.5.1  Plug welding may be adopted exceptionally as a substitute to slot welding. Typical details are given in Tab 2.
2.6 Fillet weld

2.6.1 Fillet welding types
Fillet welding may be of the following types:
- continuous fillet welding, where the weld is constituted by a continuous fillet on each side of the abutting plate
- intermittent fillet welding, 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.
- secondary stiffener of deck plating subjected to wheel loads.
Continuous fillet weld may also be adopted in lieu of intermittent welding wherever deemed suitable, and 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 throat thickness \( t_f \) of a double continuous fillet weld, in mm, is to be obtained from the following formula:

\[
t_f = w_F \cdot t \geq t_{\text{min}}
\]

where:
- \( w_F \) : Welding factor for the various hull structural elements, defined in Tab 3
- \( t \) : Actual thickness, in mm, of the thinner plate of the assembly
- \( t_{\text{min}} \) : Minimum throat thickness, in mm, taken equal to:
  - \( t_{\text{min}} = 3.0 \text{ mm} \), where the thickness of the thinner plate is less than 6 mm
  - \( t_{\text{min}} = 3.5 \text{ mm} \), otherwise.

Note 1: A lower value of \( t_{\text{min}} \) may be accepted on a case by case basis depending on the results of structural analyses.

The throat thickness \( t_f \) may be increased for particular loading conditions.

The leg length of fillet weld is to be not less than 1.4 times the throat thickness.

When fillet welding is carried out with automatic welding procedures, the throat thickness \( t_f \) 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.

### 2.6.4 Direct calculation of double continuous fillet weld

Where deemed necessary, the minimum throat thickness \( t_f \) of a double continuous fillet weld between stiffener web and associated plating and/or flange, in mm, may be determined as follows:

\[
t_f \geq \frac{T}{2 \tau} \geq t_{\text{min}}
\]

where:
- \( T \) : Shear force, in N, in the considered section of the stiffener
- \( I \) : Inertia, in \( \text{mm}^4 \), of the stiffener
- \( \tau \) : Permissible shear stress, in \( \text{N/mm}^2 \), as defined in Ch 2, Sec 3
- \( t_{\text{min}} \) : Minimum throat thickness as defined in [2.6.3]

### 2.6.5 Throat thickness of intermittent weld

The throat thickness \( t_{IT} \), in mm, of intermittent welds is to be not less than:

\[
t_{IT} = t_p \frac{p}{d}
\]

where:
- \( t_p \) : Throat, in mm, of the double continuous fillet weld, equal to:
  \( t_p = w_F \cdot t \)
  with:
  - \( w_F, t \) : As defined in [2.6.3]
- \( p, d \) : Defined as follows:
  - chain welding (see Fig 2):
    - \( d \geq 75 \text{ mm} \)
    - \( p - d \leq 200 \text{ mm} \)
  - staggered welding (see Fig 3):
    - \( d \geq 75 \text{ mm} \)
    - \( p - 2d \leq 300 \text{ mm} \)
    - \( p \leq 2d \) for connections subjected to high alternate stresses.

### 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 secondary stiffeners is to be not less than the value obtained, in mm, from the following formula:

\[
t_{IC} = t_f \frac{e}{\lambda}
\]

where:
- \( t_f \) : Throat thickness defined in [2.6.3]
- \( e, \lambda \) : Dimensions, in mm, to be taken as shown in Fig 4.

**Figure 1**: Stiffener elements definition for \( m \) calculation

---

\( m \) : Value, in \( \text{mm}^3 \), calculated as follows (see Fig 1):
- for weld between flange and web:
  \[ m = t_f b_f v_f \]
- for weld between associated plate and web:
  \[ m = t_p b_p v_p \]
Table 3 : Welding factor \( w_F \) for the various hull structural connections

<table>
<thead>
<tr>
<th>Hull area</th>
<th>Connection</th>
<th>of</th>
<th>to</th>
<th>( w_F ) (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General, unless otherwise specified in the Table</td>
<td>watertight plates boundaries</td>
<td></td>
<td></td>
<td>0,35</td>
</tr>
<tr>
<td></td>
<td>non-tight plates boundaries</td>
<td></td>
<td></td>
<td>0,20</td>
</tr>
<tr>
<td></td>
<td>strength decks side shell</td>
<td></td>
<td></td>
<td>0,45</td>
</tr>
<tr>
<td></td>
<td>webs of secondary stiffeners plating</td>
<td></td>
<td></td>
<td>0,13</td>
</tr>
<tr>
<td></td>
<td>webs of secondary stiffeners plating at ends (2)</td>
<td></td>
<td></td>
<td>0,20</td>
</tr>
<tr>
<td></td>
<td>webs of secondary stiffeners web of primary stiffener see [2.6.7]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>web of primary stiffeners plating and flange</td>
<td></td>
<td></td>
<td>0,20</td>
</tr>
<tr>
<td></td>
<td>web of primary stiffeners plating and flange at ends (2)</td>
<td></td>
<td></td>
<td>0,10 (3)</td>
</tr>
<tr>
<td></td>
<td>web of primary stiffeners bottom and inner bottom (in way of transverse and/or longitudinal bulkhead supported on tank top)</td>
<td></td>
<td></td>
<td>0,45</td>
</tr>
<tr>
<td></td>
<td>web of primary stiffeners deck (for cantilever deck beam)</td>
<td></td>
<td></td>
<td>0,45</td>
</tr>
<tr>
<td></td>
<td>web of primary stiffeners web of primary stiffeners</td>
<td></td>
<td></td>
<td>0,35</td>
</tr>
<tr>
<td>Structures located forward of 0,75 ( L ) from the aft end</td>
<td>secondary stiffeners bottom and side shell plating</td>
<td></td>
<td></td>
<td>0,20</td>
</tr>
<tr>
<td></td>
<td>primary stiffeners bottom, inner bottom and side shell plating</td>
<td></td>
<td></td>
<td>0,25</td>
</tr>
<tr>
<td>Structures located in bottom slamming area or in the first third of the platform bottom of catamaran</td>
<td>secondary stiffeners bottom plating</td>
<td></td>
<td></td>
<td>0,20</td>
</tr>
<tr>
<td></td>
<td>primary stiffeners bottom plating</td>
<td></td>
<td></td>
<td>0,25</td>
</tr>
<tr>
<td>Machinery space</td>
<td>girders bottom and inner bottom plating</td>
<td>in way of main engine foundations</td>
<td></td>
<td>0,45</td>
</tr>
<tr>
<td></td>
<td>girders bottom and inner bottom plating</td>
<td>in way of seating of auxiliary machinery</td>
<td></td>
<td>0,35</td>
</tr>
<tr>
<td></td>
<td>girders bottom and inner bottom plating</td>
<td>elsewhere</td>
<td></td>
<td>0,25</td>
</tr>
<tr>
<td></td>
<td>floors (except in way of main engine foundations) bottom and inner bottom plating</td>
<td>in way of seating of auxiliary machinery</td>
<td></td>
<td>0,35</td>
</tr>
<tr>
<td></td>
<td>floors (except in way of main engine foundations) bottom and inner bottom plating</td>
<td>elsewhere</td>
<td></td>
<td>0,25</td>
</tr>
<tr>
<td></td>
<td>floors in way of main engine foundations bottom plating</td>
<td></td>
<td></td>
<td>0,35</td>
</tr>
<tr>
<td></td>
<td>floors in way of main engine foundations foundation plates</td>
<td></td>
<td></td>
<td>0,45</td>
</tr>
<tr>
<td></td>
<td>floors centre girder single bottom</td>
<td></td>
<td></td>
<td>0,45</td>
</tr>
<tr>
<td>Superstructures and deckhouses</td>
<td>external bulkheads deck</td>
<td></td>
<td></td>
<td>0,35</td>
</tr>
<tr>
<td></td>
<td>internal bulkheads deck</td>
<td></td>
<td></td>
<td>0,13</td>
</tr>
<tr>
<td></td>
<td>secondary stiffeners external and internal bulkhead plating</td>
<td></td>
<td></td>
<td>0,13</td>
</tr>
<tr>
<td>Pillars</td>
<td>pillars deck pillars in compression</td>
<td></td>
<td></td>
<td>0,35</td>
</tr>
<tr>
<td></td>
<td>pillars deck pillars in tension</td>
<td></td>
<td></td>
<td>full penetration welding</td>
</tr>
<tr>
<td>Rudders</td>
<td>primary element directly connected to solid parts or rudder stock solid part or rudder stock</td>
<td></td>
<td></td>
<td>0,45</td>
</tr>
<tr>
<td></td>
<td>other webs each other</td>
<td></td>
<td></td>
<td>0,20</td>
</tr>
<tr>
<td></td>
<td>webs plating top and bottom plates of rudder plating</td>
<td></td>
<td></td>
<td>0,35</td>
</tr>
</tbody>
</table>

(1) For connections where \( w_F \) ≥ 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.
2.6.7 Welding between secondary and primary stiffeners

As a general rule, the resistant weld section $A_W$, in cm$^2$, of the fillet weld connecting the secondary stiffeners to the web of primary members is not to be less than:

a) General case:

$$A_W = \varphi \rho s \ell (1 - \frac{k}{2\ell}) k10^{-3}$$

where:

- $\varphi$: Coefficient as indicated in Tab 4
- $\rho$: Design pressure, in kN/m$^2$, acting on the secondary stiffeners
- $s$: Spacing of secondary stiffeners, in m
- $\ell$: Span of secondary stiffeners, in m
- $k$: Greatest material factor of secondary stiffener and primary member, as defined in Ch 1, Sec 2

b) Case of side shell impact:

$$A_W = \varphi s P (0.6 - \frac{s}{4}) k10^{-3}$$

where:

- $s$: Spacing of secondary stiffeners, in m, without being taken greater than 0.6 m

$P$ : Pressure, in kN/m$^2$, 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/m$^2$, acting on the secondary stiffeners as defined in Ch 3, Sec 3, [3.1.2].

<table>
<thead>
<tr>
<th>Case</th>
<th>Weld</th>
<th>$\varphi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Parallel to the reaction exerted on primary member</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Perpendicular to the reaction exerted on primary member</td>
<td>75</td>
</tr>
</tbody>
</table>

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 5.

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.
### Table 5: Typical butt weld plate edge preparation (manual welding) - See Note 1

<table>
<thead>
<tr>
<th>Detail</th>
<th>Standard</th>
</tr>
</thead>
</table>
| Square butt                | $t \leq 5 \text{ mm}  
                          G = 3 \text{ mm}$                |
| Single bevel butt          | $t > 5 \text{ mm}  
                          G \leq 3 \text{ mm}  
                          R \leq 3 \text{ mm}  
                          50^\circ \leq \theta \leq 70^\circ$ |
| Single vee butt            | $G \leq 3 \text{ mm}  
                          50^\circ \leq \theta \leq 70^\circ  
                          R \leq 3 \text{ mm}$                |
| Double bevel butt          | $t > 19 \text{ mm}  
                          G \leq 3 \text{ mm}  
                          R \leq 3 \text{ mm}  
                          50^\circ \leq \theta \leq 70^\circ$ |
| Double vee butt, uniform bevels | $G \leq 3 \text{ mm}  
                          R \leq 3 \text{ mm}  
                          50^\circ \leq \theta \leq 70^\circ$ |
| Double vee butt, non-uniform bevels | $G \leq 3 \text{ mm}  
                          R \leq 3 \text{ mm}  
                          6 \leq h \leq t/3 \text{ mm}  
                          \theta = 50^\circ  
                          \alpha = 90^\circ$ |

**Note 1:** Different plate edge preparation may be accepted or approved by the Society on the basis of an appropriate welding procedure specification.

### 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.

### 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](image)

#### 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 and Fig 7, in which $f$, in mm, is to be taken between 3 mm and $T/3$, and $\alpha$ between $45^\circ$ and $60^\circ$.

![Figure 6: Partial penetration weld](image)
for full penetration welds: Fig 8, in which \( f \), in mm, is to be taken between 0 and 3 mm, and \( \alpha \) between 45° and 60°.

Back gouging may be required for full penetration welds.

### 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.

#### 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.
SECTION 3  TESTING

1  Testing procedures of watertight compartments

1.1  Definitions

1.1.1  Each type of structural test (see [1.3.1]) and leak test (see [1.3.2]) is defined in Tab 1.

1.1.2  Structural test
A structural test is a test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydropneumatic test.

1.1.3  Leak test
A leak test is a test to verify the tightness of a boundary. Unless a specific test is indicated, this may be a hydrostatic/hydropneumatic test or an air test. A hose test may be considered to be an acceptable form of leak test for certain boundaries, as indicated by footnote (3) of Tab 2.

1.2  General

1.2.1  Tests are to be carried out in the presence of a Surveyor at a stage sufficiently close to the completion of work, with all the hatches, doors, windows, etc., installed and all the penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints. Specific test requirements are given in [1.6] and Tab 2. For the timing of the application of coating and the provision of safe access to joints, see [1.7], [1.8] and Tab 4.

1.3  Application

1.3.1  As a rule, tests defined in the present Section are to be carried out for ships surveyed by the Society during construction within the scope of classification. These test procedures are to confirm the watertightness of tanks and watertight boundaries, and the structural adequacy of tanks forming a part of the watertight subdivisions of ships. These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting.

The tightness of all tanks and watertight boundaries of ships during new construction and ships relevant to major conversions or major repairs is to be confirmed by these test procedures prior to the delivery of the ships.

Note 1: Major repair means a repair affecting structural integrity.

1.3.2  All gravity tanks and other boundaries required to be watertight or weathertight are to be tested in accordance with these procedures and proven tight and structurally adequate as follows:

- gravity tanks for their tightness and structural adequacy
- watertight boundaries other than tank boundaries for their watertightness
- weathertight boundaries for their weathertightness.

Note 1: Gravity tank means a tank that is subject to vapour pressure not greater than 70 kPa.

<table>
<thead>
<tr>
<th>Test types</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrostatic test (leak and structural)</td>
<td>The space to be tested is filled with a liquid to a specified head</td>
</tr>
<tr>
<td>Hydropneumatic test (leak and structural)</td>
<td>Combination of a hydrostatic test and an air test, the space to be tested being partially filled with liquid and pressurized with air</td>
</tr>
<tr>
<td>Hose test (leak)</td>
<td>Tightness check of the joint to be tested by means of a jet of water, the joint being visible from the opposite side</td>
</tr>
<tr>
<td>Air test (leak)</td>
<td>Tightness check by means of an air pressure differential and a leak-indicating solution. It includes tank air tests and joint air tests, such as compressed air fillet weld tests and vacuum box tests</td>
</tr>
<tr>
<td>Compressed air fillet weld test (leak)</td>
<td>Air test of fillet welded tee joints, by means of a leak indicating solution applied on fillet welds</td>
</tr>
<tr>
<td>Vacuum box test (leak)</td>
<td>A box over a joint with a leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks</td>
</tr>
<tr>
<td>Ultrasonic test (leak)</td>
<td>Tightness check of the sealing of closing devices such as hatch covers, by means of ultrasonic detection techniques</td>
</tr>
<tr>
<td>Penetration test (leak)</td>
<td>Check, by means of low surface tension liquids (i.e. dye penetrant test), that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment</td>
</tr>
</tbody>
</table>
## Table 2: Test requirements for tanks and boundaries

<table>
<thead>
<tr>
<th>Item</th>
<th>Tank or boundaries to be tested</th>
<th>Test type</th>
<th>Test head or pressure</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| 1    | Double bottom tanks (4)         | leak and structural (1) | The greater of:  
- top of the overflow  
- 2,4 m above top of tank (2)  
- bulkhead deck | |
| 2    | Double bottom voids (5)         | leak      | See [1.6.4] to [1.6.6], as applicable | Including pump room double bottom and bunker tank protection double hull required by MARPOL Annex I |
| 3    | Double side tanks               | leak and structural (1) | The greater of:  
- top of the overflow  
- 2,4 m above top of tank (2) (10)  
- bulkhead deck | |
| 4    | Double side voids               | leak      | See [1.6.4] to [1.6.6], as applicable | |
| 5    | Deep tanks other than those listed elsewhere in this Table | leak and structural (1) | The greater of:  
- top of the overflow  
- 2,4 m above top of tank (2) (10) | |
| 6    | Cargo oil tanks                 | leak and structural (1) | The greater of:  
- top of the overflow  
- 2,4 m above top of tank (2)  
- top of tank plus setting of any pressure relief valve (2) | |
| 7    | Ballast holds of bulk carriers  | leak and structural (1) | The greater of:  
- top of the overflow  
- top of cargo hatch coaming | |
| 8    | Peak tanks                      | leak and structural (1) | The greater of:  
- top of the overflow  
- 2,4 m above top of tank (2) (10) | After peak to be tested after installation of stern tube |
| 9    | a) Fore peak spaces with equipment | leak      | See [1.6.3] to [1.6.6], as applicable | |
|      | b) Fore peak voids              | leak and structural (1) (9) | To bulkhead deck | |
|      | c) Aft peak spaces with equipment | leak      | See [1.6.3] to [1.6.6], as applicable | After peak to be tested after installation of stern tube |
|      | d) Aft peak voids               | leak      | See [1.6.4] to [1.6.6], as applicable | |
| 10   | Cofferdams                      | leak      | See [1.6.4] to [1.6.6], as applicable | |
| 11   | a) Watertight bulkheads         | leak (8)  | See [1.6.3] to [1.6.6], as applicable (7) | |
|      | b) Superstructure end bulkheads | leak      | See [1.6.3] to [1.6.6], as applicable | |
| 12   | Watertight doors below freeboard or bulkhead deck | leak (6) (7) | See [1.6.3] to [1.6.6], as applicable | |
| 13   | Double plate rudder blades      | leak      | See [1.6.4] to [1.6.6], as applicable | |
| 14   | Shaft tunnels clear of deep tanks | leak (3)  | See [1.6.3] to [1.6.6], as applicable | |
| 15   | Shell doors                     | leak (3)  | See [1.6.3] to [1.6.6], as applicable | |
| 16   | Weathertight hatch covers and closing appliances | leak (3) (7) | See [1.6.3] to [1.6.6], as applicable | Hatch covers closed by tarpaulins and battens excluded |
| 17   | Dual purpose tank/dry cargo hatch covers | leak (3) (7) | See [1.6.3] to [1.6.6], as applicable | In addition to the structural test in item 6 or item 7 |
| 18   | Chain lockers                   | leak and structural | Head of water up to top of chain pipe | |
| 19   | L.O. sump tanks and other similar tanks/spaces under main engines | leak | See [1.6.3] to [1.6.6], as applicable | |
Table 3 : Additional test requirements for special service ships/tanks

<table>
<thead>
<tr>
<th>Item</th>
<th>Tank or boundaries to be tested</th>
<th>Test type</th>
<th>Test head or pressure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Ballast ducts</td>
<td>leak and structural (1)</td>
<td>The greater of: • ballast pump maximum pressure • setting of any pressure relief valve</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Fuel oil tanks</td>
<td>leak and structural (1)</td>
<td>The greater of: • top of the overflow • 2,4 m above top of tank (2) (10) • top of tank plus setting of any pressure relief valve (2) • bulkhead deck</td>
<td></td>
</tr>
</tbody>
</table>

(1) See [1.4.2], item a).
(2) The top of a tank is the deck forming the top of the tank, excluding any hatchways.
(3) Hose test may be also considered as a medium of the leak test. See [1.1.3].
(4) Including the tanks arranged in accordance with the provisions of NR467 Steel Ships Pt B, Ch 2, Sec 2, [3.1.4], where applicable.
(5) Including the duct keels and dry compartments arranged in accordance with the provisions of SOLAS, Regulations II-1/11.2 and II-1/9.4 respectively, and/or the oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex 1, Chapter 3, Part A, Regulation 12A and Chapter 4, Part A, Regulation 22, respectively, where applicable.
(6) Where watertightness of watertight doors has not been confirmed by a prototype test, a hydrostatic test (filling of the watertight spaces with water) is to be carried out. See SOLAS Regulation II-1/16.2 and MSC/Circ.1176.
(7) As an alternative to the hose test, other testing methods listed in [1.6.7] to [1.6.9] may be acceptable, subject to adequacy of such testing methods being verified. See SOLAS Regulation II-1/11.1. For watertight bulkheads (item 11 a)), alternatives to the hose test may be used only where the hose test is not practicable.
(8) A structural test (see [1.4.2]) is also to be carried out for a representative cargo hold in case of cargo holds intended for in-port ballasting. The filling level required for the structural test of such cargo holds is to be the maximum loading that will occur in-port, as indicated in the loading manual.
(9) Structural test may be waived where it is demonstrated to be impracticable, to the satisfaction of the Society.
(10) For ships less than 40 m, 2,4 may be replaced by \(0,9 \leq 0,3H \leq 2,4\), where \(H\) is the height of the tank, in m.

<table>
<thead>
<tr>
<th>Item</th>
<th>Type of ship/tank</th>
<th>Structure to be tested</th>
<th>Type of test</th>
<th>Test head or pressure</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Edible liquid tanks</td>
<td>Independent tanks</td>
<td>leak and structural</td>
<td>The greater of: • top of the overflow • 0,9 m above top of tank (1)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Chemical carriers</td>
<td>Integral or independent cargo tanks</td>
<td>leak and structural</td>
<td>The greater of: • 2,4 m above top of tank (1) • top of tank plus setting of any pressure relief valve (1)</td>
<td>An appropriate additional head is to be considered where a cargo tank is designed for the carriage of cargoes with specific gravities greater than 1,0</td>
</tr>
</tbody>
</table>

(1) Top of tank is deck forming the top of the tank excluding any hatchways.

Table 4 : Application of leak test, coating, and provision of safe access for the different types of welded joints

<table>
<thead>
<tr>
<th>Type of welded joints</th>
<th>Leak test</th>
<th>Coating (1)</th>
<th>Safe access (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before leak test</td>
<td>After leak test but before structural test</td>
<td>Leak test</td>
</tr>
<tr>
<td>Butt</td>
<td>Automatic</td>
<td>not required</td>
<td>allowed (3)</td>
</tr>
<tr>
<td></td>
<td>Manual or semi-automatic (4)</td>
<td>required</td>
<td>not allowed</td>
</tr>
<tr>
<td>Fillet</td>
<td>Boundary including penetrations</td>
<td>required</td>
<td>not allowed</td>
</tr>
</tbody>
</table>

(1) Coating refers to internal (tank/hold) coating, where applied, and external (shell/deck) painting. It does not refer to shop primer.
(2) Temporary means of access for verification of the leak test.
(3) The condition applies provided that the welds have been visually inspected with care, to the satisfaction of the Surveyor.
(4) Flux Core Arc Welding (FCAW) semi-automatic butt welds need not be tested, provided careful visual inspections show continuous and uniform weld profile shape, free from repairs, and the results of NDT show no significant defects.
1.3.3 Testing of structures not listed in Tab 2 or Tab 3 is to be specially considered by the Society.

1.3.4 Testing procedures of watertight compartments are defined in:

- for SOLAS ships: [1.3.5]
- for non-SOLAS ships: [1.3.6].

1.3.5 Testing procedures of watertight compartments for SOLAS Ships are to be carried out in accordance with the requirements of [1.4] to [1.9], unless:

a) the shipyard provides documentary evidence of the shipowner’s agreement to a request to the Flag Administration for an exemption from the application of SOLAS Chapter II-1, Regulation 11, or for an equivalency agreeing that the content of [1.10] is equivalent to SOLAS Chapter II-1, Regulation 11; and

b) the above-mentioned exemption/ equivalency has been granted by the responsible Flag Administration.

1.3.6 Testing procedures of watertight compartments for non-SOLAS Ships are to be carried out in accordance with the requirements of [1.4.1] and [1.5] to [1.9] in association with the alternative procedures to [1.4.2] defined in [1.10] and alternative test requirements for Tab 2.

1.4 Structural test procedures

1.4.1 Type and time of test

Where a structural test is specified in Tab 1 or Tab 2, a hydrostatic test in accordance with [1.6.1] is acceptable. Where practical limitations (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with [1.6.2] may be accepted instead.

A hydrostatic or hydropneumatic test for the confirmation of structural adequacy may be carried out while the ship is afloat, provided the results of a leak test are confirmed to be satisfactory before the ship is set afloat.

1.4.2 Testing schedule for new construction and major structural conversion or repair

a) Tanks which are intended to hold liquids, and which form part of the watertight subdivision of the ship, shall be tested for tightness and structural strength as indicated in Tab 2 and Tab 3.

b) The tank boundaries are to be tested from at least one side. The tanks for the structural test are to be selected so that all the representative structural members are tested for the expected tension and compression.

c) The watertight boundaries of spaces other than tanks may be exempted from the structural test, provided that the boundary watertightness of the exempted spaces is verified by leak tests and inspections. The tank structural test is to be carried out and the requirements from item a) to item b) are to be applied for ballast holds, chain lockers, and for a representative cargo hold in case of cargo holds intended for in-port ballasting.

d) Tanks which do not form part of the watertight subdivision of the ship, may be exempted from structural testing provided that the boundary watertightness of the exempted spaces is verified by leak tests and inspections.

1.5 Leak test procedures

1.5.1 For the leak tests specified in Tab 2, tank air tests, compressed air fillet weld tests and vacuum box tests, in accordance respectively with [1.6.3], [1.6.5] and [1.6.6], or their combinations, are acceptable. Hydrostatic or hydropneumatic tests may be also accepted as leak tests, provided [1.7], [1.8] and [1.9] are complied with. Hose tests, in accordance with [1.6.3], are also acceptable for items 14 to 17 referred to in Tab 2, taking footnote (3) into account.

1.5.2 Air tests of joints may be carried out at the block stage, provided that all work on the block that may affect the tightness of a joint is completed before the test. See also [1.7.1] for the application of final coatings, [1.8] for the safe access to joints, and Tab 4 for the summary.

1.6 Test methods

1.6.1 Hydrostatic test

Unless another liquid is approved, hydrostatic tests are to consist in filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in Tab 2 or Tab 3.

In case where a tank is intended for cargoes having a density higher than the density of the liquid used for the test, the testing pressure height is to be specially considered.

All the external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, any other related damage, and leaks.

1.6.2 Hydropneumatic test

Hydropneumatic tests, where approved, are to be such that the test condition, in conjunction with the approved liquid level and supplemental air pressure, simulates the actual loading as far as practicable. The requirements and recommendations in [1.6.4] for tank air tests apply also to hydropneumatic tests.

All the external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, any other related damage, and leaks.

1.6.3 Hose test

Hose tests are to be carried out with the pressure in the hose nozzle maintained at least at 2·10^5 Pa during the test. The nozzle is to have a minimum inside diameter of 12 mm and to be at a perpendicular distance from the joint not exceeding 1,5 m. The water jet is to impinge upon the weld.

Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation, or outfitting items, it may be replaced by a careful visual examination of the welded connections, supported where necessary by means such as a dye penetrant test or an ultrasonic leak test, or equivalent.
1.6.4  Tank air test

All boundary welds, erection joints and penetrations including pipe connections are to be examined in accordance with approved procedures and under a stabilized pressure differential above atmospheric pressure not less than 0,15·10^5 Pa, with a leak-indicating solution (such as soapy water/detergent or a proprietary solution) applied.

A U-tube having a height sufficient to hold a head of water corresponding to the required test pressure is to be arranged. The cross-sectional area of the U-tube is not to be less than that of the pipe supplying air to the tank.

Note 1: Arrangements involving the use of two calibrated pressure gauges to verify the required test pressure may be accepted taking into account the provisions in F5.1 and F7.4 of IACS Recommendation 140, “Recommendation for Safe Precautions during Survey and Testing of Pressurized Systems”

A double inspection of the tested welds is to be carried out. The first inspection is to be made immediately upon application of the leak indication solution; the second one is to be made approximately four or five minutes after, in order to detect those smaller leaks which may take time to appear.

1.6.5  Compressed air fillet weld test

In this air test, compressed air is injected from one end of a fillet welded joint, and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges are to be arranged so that an air pressure of at least 0,15·10^5 Pa can be verified at each end of any passage within the portion being tested.

Note 1: Where a leak test is required for fabrication involving partial penetration welds, a compressed air test is also to be carried out in the same manner as to fillet weld where the root face is large, i.e. 6-8 mm.

1.6.6  Vacuum box test

A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak-indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of 0,20·10^-5 to 0,26·10^-5 Pa inside the box.

1.6.7  Ultrasonic test

An ultrasonic echo transmitter is to be arranged on the inside of a compartment, and a receiver on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver, in order to detect an ultrasonic leak indication. Any leakage in the sealing of the compartment is indicated at a location where sound is detectable by the receiver.

1.6.8  Penetration test

For the test of butt welds or other weld joints, a low surface tension liquid is applied on one side of a compartment boundary or a structural arrangement. If no liquid is detected on the opposite sides of the boundaries after the expiration of a defined period of time, this indicates tightness of the boundaries. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection.

1.6.9  Other test

Other methods of testing may be considered by the Society upon submission of full particulars prior to the commencement of the tests.

1.7  Application of coating

1.7.1  Final coating

For butt joints welded by means of an automatic process, the final coating may be applied at any time before completion of a leak test of the spaces bounded by the joints, provided that the welds have been visually inspected with care, to the satisfaction of the Surveyor.

The Surveyors reserve the right to require a leak test prior to the application of a final coating over automatic erection butt welds.

For all the other joints, the final coating is to be applied after the completion of the joint leak test. See also Tab 4.

1.7.2  Temporary coating

Any temporary coating which may conceal defects or leaks is to be applied at the same time as for a final coating (see [1.7.1]). This requirement does not apply to shop primers.

1.8  Safe access to joints

1.8.1  For leak tests, a safe access to all joints under examination is to be provided. See also Tab 4.

1.9  Hydrostatic or hydropneumatic tightness test

1.9.1  In cases where the hydrostatic or hydropneumatic tests are applied instead of a specific leak test, the examined boundaries are to be dew-free, otherwise small leaks are not visible.

1.10  Testing procedures for non-Solas ships

1.10.1  With reference to [1.3.6], testing procedures are to be carried out in accordance with the requirements of [1.4.1] and [1.5] to [1.9] in association with the following alternative procedures for [1.4.2] and alternative test requirements for Tab 2.

1.10.2  The tank boundaries are to be tested from at least one side. The tanks for structural test are to be selected so that all representative structural members are tested for the expected tension and compression.

1.10.3  Structural tests are to be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localised differences determined to be acceptable by the attending Surveyor) on each vessel provided all other tanks are tested for leaks by an air test. The acceptance of leak testing using an air test instead of a structural test does not apply to cargo space boundaries adjacent to other compartments in tankers and combination carriers or to the boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships.
1.10.4 Additional tanks may require structural testing if found necessary after the structural testing of the first tank.

1.10.5 Where the structural adequacy of the tanks of a vessel were verified by the structural testing required in Tab 2, subsequent vessels in the series (i.e. sister ships built from the same plans at the same shipyard) may be exempted from structural testing of tanks, provided that:

a) Water-tightness of boundaries of all tanks is verified by leak tests and thorough inspections are carried out.

b) Structural testing is carried out for at least one tank of each type among all tanks of each sister vessel.

c) Additional tanks may require structural testing if found necessary after the structural testing of the first tank or if deemed necessary by the attending Surveyor.

For cargo space boundaries adjacent to other compartments in tankers and combination carriers or boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships, the provisions of [1.10.3] shall apply in lieu of item b).

1.10.6 Sister ships built (i.e. keel laid) two years or more after the delivery of the last ship of the series, may be tested in accordance with [1.10.5] at the discretion of the Society, provided that:

a) general workmanship has been maintained (i.e. there has been no discontinuity of shipbuilding or significant changes in the construction methodology or technology at the yard, shipyard personnel are appropriately qualified and demonstrate an adequate level of workmanship as determined by the Society); and

b) an NDT plan is implemented and evaluated by the Society for the tanks not subject to structural tests. Shipbuilding quality standards for the hull structure during new construction are to be reviewed and agreed during the kick-off meeting. Structural fabrication is to be carried out in accordance with IACS Recommendation 47, “Shipbuilding and Repair Quality Standard”, or a recognised fabrication standard which has been accepted by the Society prior to the commencement of fabrication/construction. The work is to be carried out in accordance with the Rules and under survey of the Society.

2 Miscellaneous

2.1 Watertight decks, trunks, etc.

2.1.1 After completion, a hose or flooding test is to be applied to watertight decks and a hose test to watertight trunks, tunnels and ventilators.

2.2 Steering nozzles

2.2.1 Upon completion of manufacture, the nozzle is to be subjected to a leak test.
SECTION 4 CONSTRUCTION SURVEY

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 ships and/or certification of ship hulls built in steel materials.

Equivalent requirements are defined in:
- NR561 Aluminium Ships, for ships built in aluminium
- NR546 Composite Materials, for ships built in composite materials.

The scope of classification is defined in NR467 Steel Ships, Part A.

2 Structure drawing examination

2.1 General

2.1.1 The structure drawings submitted within the scope of 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 Sec 2, [1.3.1] 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:

a) 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.

b) 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 5, Sec 2 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 (HHH) 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.

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.

3.4.3 Welding procedures

Welding procedures adopted are to be approved by the Society as defined in NR216 Materials and Welding, Ch 5, Sec 4.

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).

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.

<table>
<thead>
<tr>
<th>Steel grade</th>
<th>Butt welding, partial and full T penetration welding</th>
<th>Fillet welding</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>B - D</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>AH32 - AH36</td>
<td>2Y</td>
<td></td>
</tr>
<tr>
<td>DH32 - DH36</td>
<td>2Y</td>
<td></td>
</tr>
<tr>
<td>EH32 - EH36</td>
<td>3Y</td>
<td></td>
</tr>
</tbody>
</table>

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.

Table 1: Minimum consumable grades
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, 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 5, Sec 3.

### 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 and 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 \( B + C \leq 15 \text{ m} \), 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.

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.