Rules for the Classification of Ships

Effective from 1 January 2024

Part B

Hull and Stability

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GENERAL CONDITIONS

Definitions:

"*Administration*" means the Government of the State whose flag the Ship is entitled to fly or under whose authority the Ship is authorised to operate in the specific case.

"IACS" means the International Association of Classification Societies.

"*Interested Party*" means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the ship builder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

"*Owner*" means the registered owner, the ship owner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the specific Rules.

"Rules" in these General Conditions means the documents below issued by the Society:

- (i) Rules for the Classification of Ships or other special units;
- (ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
- (iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
- (iv) Guides to carry out particular activities connected with Services;
- (v) Any other technical document, as for example rule variations or interpretations.

"*Services*" means the activities described in Article 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

"Ship" means ships, boats, craft and other special units, as for example offshore structures, floating units and underwater craft.

"*Society*" or *"TASNEEF"* means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

"*Surveyor*" means technical staff acting on behalf of the Society in performing the Services.

Article 1

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
- (i) sets forth and develops Rules;
- (ii) publishes the Register of Ships;
- (iii) issues certificates, statements and reports based on its survey activities.

1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various G overnments.

1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which are regulated by these general conditions, unless expressly excluded in the particular contract.

Article 2

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published. Therefore, the Society, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

2.2. The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatemen t. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.
The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.

2.3. The Society exercises due care and skill:
- (i) in the selection of its Surveyors
- (ii) in the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.

2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or of the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

Article 3

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of th e specific scope of the Service requested by the Interested Party or on its behalf.

3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as p art of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

3.3. The classification of a Ship, or the issuance of a certificate or other document connected with classification or certificati on and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaw orthiness, structural integrity, quality or fitness for a particular purpose or service of any Ship, structur e, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society in relation to its activities reflects the condition of the Ship or the subject of certifi cation or other activity at the time of the check.

3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, t he Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.

In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.

In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.

Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

4.1. Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

4.2. In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.

For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.

With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any st atutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

5.2. Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

5.3. Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

Article 6

6.1. These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

6.2. However,

(i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and

(ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.

In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the righ t to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorisation of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of cl ass, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.
Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's c lients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific propert y of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

7.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificat es, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty t o ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.
In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

Article 8

8.1. Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

EXPLANATORY NOTE TO PART B

1. Reference edition

The reference edition for Part B is the Tasneef Rules 2000 edition, which is effective from 1 June 2000.

2. Amendments after the reference edition

2.1 Tasneef Rules 2000 has been completely rewritten and reorganised.

2.2 Except in particular cases, the Rules are updated and published annually.

3. Effective date of the requirements

3.1 All requirements in which new or amended provisions with respect to those contained in the reference edition have been introduced are followed by a date shown in brackets.

The date shown in brackets is the effective date of entry into force of the requirements as amended by the last updating. The effective date of all those requirements not followed by any date shown in brackets is that of the reference edition.

3.2 Item 6 below provides a summary of the technical changes from the preceding edition. In general, this list does not include those items to which only editorial changes have been made not affecting the effective date of the requirements contained therein.

4. Rule Variations and Corrigenda

Until the next edition of the Rules is published, Rule Variations and/or corrigenda, as necessary, will be pub-lished on the Tasneef web site (www.Tasneef.ae). Except in particular cases, paper copies of Rule Variations or cor-rigenda are not issued.

5. Rule subdivision and cross-references

5.1 Rule subdivision

The Rules are subdivided into six parts, from A to F.

Part A: Classification and Surveys

Part B: Hull and Stability

Part C: Machinery, Systems and Fire Protection

Part D: Materials and Welding

Part E: Service Notations

Part F: Additional Class Notations

Each Part consists of:

- Chapters
- Sections and possible Appendices
- Articles
- Sub-articles
- Requirements

Figures (abbr. Fig) and Tables (abbr. Tab) are numbered in ascending order within each Section or Appendix.

5.2 Cross-references

Examples: Pt A, Ch 1, Sec 1, [3.2.1]or Pt A, Ch 1, App 1, [3.2.1]

- Pt A means Part A

The part is indicated when it is different from the part in which the cross-reference appears. Otherwise, it is not indicated.

- Ch 1 means Chapter 1

The Chapter is indicated when it is different from the chapter in which the cross-reference appears. Otherwise, it is not indicated.

- Sec 1 means Section 1 (or App 1 means Appendix 1)

The Section (or Appendix) is indicated when it is different from the Section (or Appendix) in which the cross-reference appears. Otherwise, it is not indicated.

- [3.2.1] refers to requirement 1, within sub-article 2 of article 3.

Cross-references to an entire Part or Chapter are not abbreviated as indicated in the following examples:

- Part A for a cross-reference to Part A
- Part A, Chapter 1 for a cross-reference to Chapter 1 of Part A.

6. Summary of amendments introduced in the edition effective from 1 January 2024

This edition of Part B contains amendments whose effective date is **1 January 2024**.

The date of entry into force of each new or amended item is shown in brackets after the number of the item concerned.

RULES FOR THE CLASSIFICATION OF SHIPS

Part B
Hull and Stability

Chapters **1 2 3 4** 5 6 7 8 9 10 11 12

CHAPTER 1
GENERAL

Section 1 Application

Section 2 Symbols and Definitions

Section 3 Documentation to be Submitted

Section 4 Calculation Programs

CHAPTER 2
GENERAL ARRANGEMENT DESIGN

Section 1 Subdivision Arrangement

Section 2 Compartment Arrangement

Section 3 Access Arrangement

CHAPTER 3
STABILITY

Section 1 General

Section 2 Intact Stability

CHAPTER 4
STRUCTURE DESIGN PRINCIPLES

Section 4 Bottom Structure

Section 5 Side Structure

Section 6 Deck Structure

Section 7 Bulkhead Structure

Part B

Hull and Stability

Chapter 1

GENERAL

SECTION 1 APPLICATION

1 General

1.1 Structural requirements

1.1.1 *(1/7/2022)*

Part B contains the requirements for determination of the minimum hull scantlings, applicable to all types of seagoing monohull displacement ships of normal form, speed and proportions, made in welded steel construction, except for bulk carriers and oil tankers, for which the requirements in the "Common Structural Rules for Bulk Carriers and Oil Tankers" apply. These requirements are to be integrated with those specified in Part E, for any individual ship type, and in Part F, as applicable, depending on the additional class notations assigned to the ships.

For ships with the notations **bulk carrier ESP CSR** and **oil tanker ESP CSR,** the above-mentioned Common Structural Rules apply as appropriate with the addition of the following requirements:

- Sec 4 - as regards the calculation programs
- Ch 3, Sec 1, Ch 3, Sec 2, Ch 3, App 1 and Ch 3, App 2 - for the requirements concerning Intact Stability
- Ch 5, Sec 1, [2.1.4] - for the direct calculations of hull girder wave induced loads in the case of ships with scantling length greater than 350 m
- Ch 5, Sec 6, [2.2] and [2.3] - for the calculation of impact pressures in tanks in the case of resonance
- Ch 9, Sec 1, [4.2] - for the bow impact pressure, only in case the applicable formulation in "Common Structural Rules for Bulk Carriers and Oil Tankers" is found to be out of its scope of application
- Ch 9, Sec 7, [1.2] - for the materials of the hatch covers
- Ch 10, Sec 1 and Ch 10, App 1 - for the requirements concerning rudders
- Ch 10, Sec 4, as applicable - for the requirements concerning ship equipment
- Ch 10, App 2 - for the requirements concerning mooring lines for ships with EN > 2000
- Ch 10, App 3 - for the requirements concerning direct mooring analyses
- Ch 11, Sec 2, [4] - for the requirements concerning the loading instruments
- Ch 12, Sec 3, [1], [2] and [3] - for the requirements concerning testing.

1.1.2 The requirements of Part B, Part E and Part F apply also to those steel ships in which parts of the hull, e.g. superstructures or movable decks, are built in aluminium alloys.

1.1.3 Ships whose hull materials are different than those given in [1.1.2] and ships with novel features or unusual hull design are to be individually considered by the Society, on the basis of the principles and criteria adopted in the Rules.

1.1.4 The strength of ships constructed and maintained according to the Rules is sufficient for the draught corresponding to the assigned freeboard. The scantling draught considered when applying the Rules is to be not less than that corresponding to the assigned freeboard.

1.1.5 Where scantlings are obtained from direct calculation procedures which are different from those specified in Chapter 7, adequate supporting documentation is to be submitted to the Society, as detailed in Sec 3.

1.2 Limits of application to lifting appliances

1.2.1 The fixed parts of lifting appliances, 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.

1.2.2 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.

2 Rule application

2.1 Ship parts

2.1.1 General

For the purpose of application of the Rules, the ship is considered as divided into the following three parts:

- fore part
- central part
- aft part.

2.1.2 Fore part

The fore part includes the structures located forward of the collision bulkhead, i.e.:

- the fore peak structures
- the stems.

In addition, it includes:

- the reinforcements of the flat bottom forward area
- the reinforcements of the bow flare area.

2.1.3 Central part

The central part includes the structures located between the collision bulkhead and the after peak bulkhead.

Where the flat bottom forward area or the bow flare area extend aft of the collision bulkhead, they are considered as belonging to the fore part.

2.1.4 Aft part

The aft part includes the structures located aft of the after peak bulkhead.

2.2 Rules applicable to various ship parts

2.2.1 The various Chapters and Sections of Part B are to be applied for the scantling of ship parts according to Tab 1.

2.3 Rules applicable to other ship items

2.3.1 The various Chapters and Sections of Part B are to be applied for the scantling of other ship items according to Tab 2.

Table 1 : Part B Chapters and Sections applicable for the scantling of ship parts

<table>
<tr><th rowspan="2">Part</th><th colspan="2">Applicable Chapters and Sections</th></tr>
<tr><th>General</th><th>Specific</th></tr>
<tr><td>Fore part</td><td rowspan="4">Chapter 1
Chapter 2
Chapter 3
Chapter 4
Chapter 9 (1), excluding:
• Ch 9, Sec 1
• Ch 9, Sec 2
Chapter 11
Chapter 12</td><td>Ch 9, Sec 1</td></tr>
<tr><td>Central part
L ≥ 90 m</td><td>Chapter 5
Chapter 6
Chapter 7</td></tr>
<tr><td>Central part
L < 90 m</td><td>Chapter 8</td></tr>
<tr><td>Aft part</td><td>Ch 9, Sec 2</td></tr>
<tr><td colspan="3">(1) See also [2.3].</td></tr>
</table>

3 Rounding off of scantlings

3.1

3.1.1 Plate thicknesses

Thicknesses as calculated in accordance with the rule requirements are to be rounded off to the nearest half-millimetre.

3.1.2 Stiffener section moduli

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%.

Table 2 : Part B Chapters and Sections applicable for the scantling of other items

Item	Applicable Chapter and Section
Machinery space	Ch 9, Sec 3
Superstructures and deckhouses	Ch 9, Sec 4
Bow doors and inner doors	Ch 9, Sec 5
Side shell doors and stern doors	Ch 9, Sec 6
Hatch covers	Ch 9, Sec 7
Movable decks and inner ramp External ramps	Ch 9, Sec 8
Rudders	Ch 10, Sec 1
Other hull outfitting	Ch 10, Sec 2 Ch 10, Sec 3 Ch 10, Sec 4

SECTION 2 SYMBOLS AND DEFINITIONS

1 Units

1.1

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

2 Symbols

2.1

2.1.1 *(1/7/2020)*

L : Rule length, in m, defined in [3.1]

L_1 : L, but to be taken not greater than 200 m

L_2 : L, but to be taken not greater than 120 m

L_{LL} : Freeboard length, in m, defined in [3.2]

B : Moulded breadth, in m, defined in [3.4]

D : Depth, in m, defined in [3.5]

T : Scantling draught, in m, defined in [3.6]

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

C_B : Total block coefficient

$$C_B = \frac{\Delta}{1,025LBT}$$

3 Definitions

3.1 Rule length

3.1.1 *(1/7/2020)*

The rule length L is the distance, in m, measured on the waterline at the scantling draught, from the forward 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 not less than 96% and need not exceed 97% of the extreme length on the waterline at the scantling draught.

3.1.2 *(1/7/2020)*

In ships without rudder stock (e.g. ships fitted with azimuth thrusters), the rule length L is to be taken equal to 97% of the extreme length on the waterline at the scantling draught.

3.1.3 In ships with unusual stem or stern arrangements, the rule length L is considered on a case by case basis.

3.2 Freeboard length

3.2.1 The freeboard 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 extreme length on the same waterline.

Table 1 : Units

Designation	Usual symbol	Units
Ship’s dimensions	See [2]	m
Hull girder section modulus	Z	m^3
Density	ρ	t/m^3
Concentrated loads	P	kN
Linearly distributed loads	q	kN/m
Surface distributed loads (pressures)	p	kN/m^2
Thicknesses	t	mm
Span of ordinary stiffeners and primary supporting members	ℓ	m
Spacing of ordinary stiffeners and primary supporting members	s	m
Bending moment	M	kN.m
Shear force	Q	kN
Stresses	σ, τ	N/mm^2
Section modulus of ordinary stiffeners and primary supporting members	w	cm^3
Sectional area of ordinary stiffeners and primary supporting members	A	cm^2

3.2.2 Where the stem contour is concave above the waterline at 85% of the least moulded depth, both the forward end of the extreme length and the forward side of the stem are to be taken at the vertical projection to that waterline of the aftermost point of the stem contour (above that waterline).

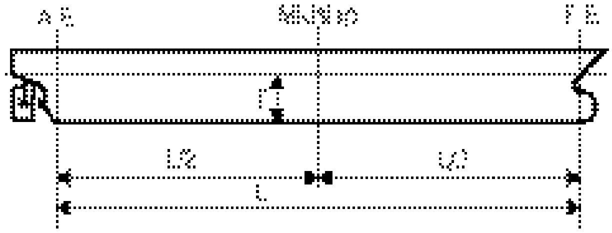
3.2.3 In ship design with a rake of keel, the waterline on which this length is measured is to be parallel to the designed waterline.

3.3 Ends of rule length L and midship

3.3.1 Fore end *(1/7/2020)*

The fore end (FE) of the rule length L, see Fig 1, is the perpendicular to the waterline at the scantling draught T taken at the forward side of the stem.

Figure 1 : Ends and midship



3.3.2 Aft end

The aft end (AE) of the rule length L, see Fig 1, is the perpendicular to the waterline at a distance L aft of the fore end.

3.3.3 Midship

The midship is the perpendicular to the waterline at a distance 0,5L aft of the fore end.

3.4 Moulded breadth

3.4.1 *(1/7/2020)*

The moulded breadth B is the greatest moulded breadth, in m, measured amidships at the scantling draught T.

3.5 Depth

3.5.1 The depth D 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 side on the uppermost continuous deck.

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

3.6 Scantling draught

3.6.1 *(1/7/2020)*

The scantling draught T is the distance, in m, measured vertically on the midship transverse section, from the moulded base line to the load line at which the strength requirements for the scantlings of the ship are met and represents the full load condition. The scantling draught is to be not less than that corresponding to the assigned freeboard.

In the case of ships with a solid bar keel, the moulded base line is to be taken as defined in [3.5.1].

3.7 Lightweight

3.7.1 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.

3.8 Deadweight

3.8.1 The deadweight is the difference, in t, between the displacement, at the summer draught in sea water of density $\rho = 1,025$ t/m^3, and the lightweight.

3.9 Freeboard deck

3.9.1 The freeboard deck is defined in Regulation 3 of the 1966 International Convention on Load Lines, in force.

3.10 Superstructure

3.10.1 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.

3.10.2 Enclosed and open superstructure

A superstructure may be:

- *enclosed, where:*
  - *it is enclosed by front, side and aft bulkheads complying with the requirements of Ch 9, Sec 4*
  - *all front, side and aft openings are fitted with efficient weathertight means of closing,* complying with the requirements in Ch 9, Sec 9
- open, where it is not enclosed.

3.11 Raised quarterdeck

3.11.1 A raised quarterdeck is a partial superstructure of reduced height as defined in [3.14].

3.12 Deckhouse

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

3.13 Trunk

3.13.1 A trunk is a decked structure similar to a deckhouse, but not provided with a lower deck.

3.14 Standard height of superstructure

3.14.1 *The standard height of superstructure is defined in Tab 2.*

Table 2 : Standard height of superstructure

Freeboard length L_{LL}, in m	Standard height h_S, in m	
	Raised quarter deck	All other superstructures
$L_{LL} \le 30$	0,90	1,80
$30 < L_{LL} < 75$	$0,9 + 0,00667(L_{LL} - 30)$	1,80

Freeboard length L_{LL} , in m	Standard height h_S, in m	
	Raised quarter deck	All other superstructures
$75 \leq L_{LL} < 125$	$1,2 + 0,012(L_{LL} - 75)$	$1,8 + 0,01(L_{LL} - 75)$
$L_{LL} \geq 125$	1,80	2,30

3.15 Type A and Type B ships

3.15.1 Type A ship

A Type A ship is one which:

- *is designed to carry only liquid cargoes in bulk;*
- *has a high integrity of the exposed deck with only small access openings to cargo compartments, closed by watertight gasketed covers of steel or equivalent material; and*
- *has low permeability of loaded cargo compartments.*

A Type A ship is to be assigned a freeboard following the requirements reported in the International Load Line Convention 1966, as amended.

3.15.2 Type B ship

All ships which do not come within the provisions regarding Type A ships stated in [3.15.1] are to be considered as Type B ships.

A Type B ship is to be assigned a freeboard following the requirements reported in the International Load Line Convention 1966, as amended.

3.15.3 Type B-60 ship

A Type B-60 ship is any Type B ship of over 100 metres in length which, fulfilling the requirements reported in Regulation 27 of Part 3, Annex I, Chapter III of the International Convention on Load Lines, 1966 and Protocol of 1988, as amended, is assigned with a value of tabular freeboard which can be reduced up to 60 per cent of the difference between the “B” and “A” tabular values for the appropriate ship lengths.

3.15.4 Type B-100 ships

A Type B-100 ship is any Type B ship of over 100 metres in length which, fulfilling the requirements reported in Regulation 27 of Part 3, Annex I, Chapter III of the International Convention on Load Lines, 1966 and Protocol of 1988, as amended, is assigned with a value of tabular freeboard which can be reduced up to 100 per cent of the difference between the “B” and “A” tabular values for the appropriate ship lengths.

3.16 Positions 1 and 2

3.16.1 Position 1

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.*

3.16.2 Position 2 *(1/1/2005)*

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 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 two standard heights of superstructure above the freeboard deck.*

4 Reference co-ordinate system

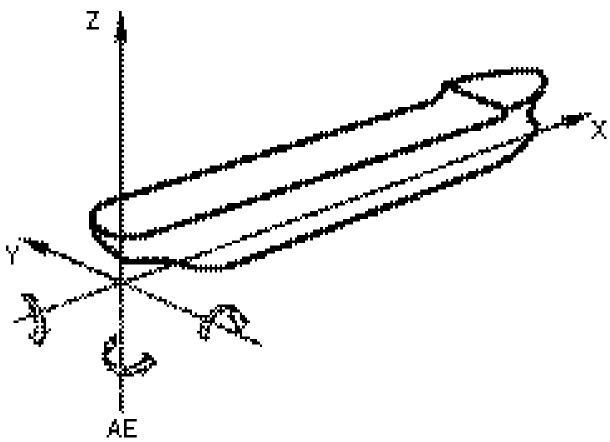
4.1

4.1.1 The ship’s geometry, motions, accelerations and loads are defined with respect to the following right-hand co-ordinate system (see Fig 2):

- Origin: at the intersection among 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.

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

Figure 2 : Reference co-ordinate system



SECTION 3 DOCUMENTATION TO BE SUBMITTED

1 Documentation to be submitted for all ships

1.1 Ships built under the Society's supervision

1.1.1 Plans and documents to be submitted for approval

The plans and documents to be submitted to the Society for approval are listed in Tab 1. This list is intended as guidance for the complete set of information to be submitted, rather than an actual list of titles.

The above plans and documents are to be supplemented by further documentation which depends on the service notation and, possibly, the additional class notation (see Pt A, Ch 1, Sec 2) assigned to the ship, as specified in [2].

Structural plans are to show details of connections of the various parts and, in general, are to specify the materials used, including their manufacturing processes, welded procedures and heat treatments. See also Ch 12, Sec 1, [1.6].

1.1.2 Plans and documents to be submitted for information *(1/7/2011)*

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

- general arrangement
- capacity plan, indicating the volume and position of the centre of gravity of all compartments and tanks
- lines plan
- hydrostatic curves
- lightweight distribution
- towing and mooring arrangement plan, containing the information specified in Ch 10, Sec 4, [3.1]
- list of dangerous goods intended to be carried, if any.

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

1.1.3 Number of copies

The number of copies to be submitted for each plan or document is to be agreed with the Society on a case by case basis depending on the specific conditions under which plan approval and supervision during construction are organised. However, it is generally equal to:

- 3 for plans and documents submitted for approval
- 2 for plans and documents submitted for information.

2 Further documentation to be submitted for ships with certain service notations or additional class notations

2.1 General

2.1.1 Depending on the service notation and, possibly, the additional class notation (see Pt A, Ch 1, Sec 2) assigned to the ship, other plans or documents may be required to be submitted to the Society, in addition to those in [1.1]. They are listed in [2.2] and [2.3] for the service notations and additional class notations which require this additional documentation.

However, the additional documentation relevant to a service notation or an additional class notation may be required also for ships to which it is not assigned, when this is deemed necessary by the Society on the basis, inter alia, of the ship service, the structural arrangements, the type of cargo carried and its containment.

2.2 Service notations

2.2.1 The plans or documents to be submitted to the Society are listed in Tab 2.

2.3 Additional class notations

2.3.1 The plans or documents to be submitted to the Society are listed in Tab 3.

Table 1 : Plans and documents to be submitted for approval for all ships *(1/7/2015)*

Plan or document	Containing also information on
Midship section Transverse sections Shell expansion Decks and profiles Double bottom Pillar arrangements Framing plan Deep tank and ballast tank bulkheads, wash bulkheads	Class characteristics Main dimensions Minimum ballast draught Frame spacing Contractual service speed Density of cargoes Design loads on decks and double bottom Steel grades Location and height of air vent outlets of various compartments Corrosion protection Openings in decks and shell and relevant compensations Boundaries of flat areas in bottom and sides Details of structural reinforcements and/or discontinuities Bilge keel with details of connections to hull structures
Loading manual and loading instruments	See Ch 11, Sec 2, [3]
Watertight subdivision bulkheads Watertight tunnels	Openings and their closing appliances, if any
Fore part structure	Location and height of air vent outlets of various compartments
Transverse thruster, if any, general arrangement, tunnel structure, connections of thruster with tunnel and hull structures	
Aft part structure	Location and height of air vent outlets of various compartments
Machinery space structures Foundations of propulsion machinery and boilers	Type, power and r.p.m. of propulsion machinery Mass and centre of gravity of machinery and boilers
Superstructures and deckhouses Machinery space casing	Extension and mechanical properties of the aluminium alloy used (where applicable)
Bow doors, stern doors and inner doors, if any, side doors and other openings in the side shell	Closing appliances 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
Hatch covers, if any	Design loads on hatch covers Sealing and securing arrangements, type and position of locking bolts Distance of hatch covers from the summer load waterline and from the fore end
Movable decks and ramps, if any	
Windows and side scuttles, arrangements and details	
Scuppers and sanitary discharges	
Bulwarks and freeing ports	Arrangement and dimensions of bulwarks and freeing ports on the freeboard deck and superstructure deck
Rudder and rudder horn **(1)**	Maximum ahead service speed

(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. For azimuth propulsion systems, see Ch 10, Sec 1, [11].
(2) Apply to ships of 500 gross tonnage and upwards.
(3) Apply to ships of 80 m or more in length, where the height of the exposed deck in way of the item is less than 0,1L or 22 m above the summer load waterline, whichever is the lesser.

Plan or document	Containing also information on
Sternframe or sternpost, sterntube Propeller shaft boss and brackets **(1)**	
Derricks and cargo gear Cargo lift structures	Design loads (forces and moments) Connections to the hull structures
Sea chests, stabiliser recesses, etc.	
Hawse pipes	
Plan of outer doors and hatchways	
Plan of manholes	
Plan of access to and escape from spaces	
Plan of ventilation	Use of spaces
Plan of tank testing	Testing procedures for the various compartments Height of pipes for testing
Plan of watertight doors and scheme of relevant manoeuvring devices	Manoeuvring devices Electrical diagrams of power control and position indication circuits
Freeboard calculations	
Stability documentation	See Ch 3, Sec 1, [3.1]
Calculations relevant to intact stability	
Equipment number calculation	Geometrical elements for calculation List of equipment Construction and breaking load of steel wires Material, construction, breaking load and relevant elongation of synthetic ropes
Helicopter deck, if any	General arrangement Main structure Characteristics of helicopters: maximum mass, distance between axles of wheels or skids, print area of wheels or skids, rotor diameter
Emergency towing arrangement	See Ch 10, Sec 4, [4.3]
Windlass	Design loads, scantlings and connections to the hull structures
Towing and mooring arrangements **(2)**	Design loads, scantlings and connections to the hull structures
Ventilator pipes within forward quarter length of the ship **(3)**	Scantlings and connections to the hull structures

(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. For azimuth propulsion systems, see Ch 10, Sec 1, [11].

(2) Apply to ships of 500 gross tonnage and upwards.

(3) Apply to ships of 80 m or more in length, where the height of the exposed deck in way of the item is less than 0,1L or 22 m above the summer load waterline, whichever is the lesser.

Table 2 : Plans and documents to be submitted depending on service notations *(1/1/2022)*

Service notations	Plans or documents
ro-ro passenger ship **ro-ro cargo ship**	Plans of the bow or stern ramps, elevators for cargo handling and movable decks, if any, including: • structural arrangements of ramps, elevators and movable decks with their masses • arrangements of securing and locking devices • connection of ramps, lifting and/or hoisting appliances to the hull structures, with indication of design loads (amplitude and direction) • wire ropes and hoisting devices in working and stowed position • hydraulic jacks • loose gear (blocks, shackles, etc.) indicating the safe working loads and the testing loads • test conditions Operating and maintenance manual (see Ch 9, Sec 5 and Ch 9, Sec 6) of bow and stern doors and ramps Plan of arrangement of motor vehicles, railway cars and/or other types of vehicles which are intended to be carried Characteristics of motor vehicles, railways cars and/or other types of vehicles which are intended to be carried: (as applicable) axle load, axle spacing, number of wheels per axle, wheel spacing, size of tyre print Plan of dangerous areas, in the case of ships intended for the carriage of motor vehicles with petrol in their tanks
container ship	Container arrangement in holds, on decks and on hatch covers, indicating size and gross mass of containers Container lashing arrangement indicating securing and load bearings arrangements Drawings of load bearing structures and cell guides, indicating the design loads and including the connections to the hull structures and the associated structural reinforcements
livestock carrier	Livestock arrangement Distribution of fodder and consumable liquid on the various decks and platforms
oil tanker ESP **FLS tanker**	Arrangement of pressure/vacuum valves in cargo tanks Cargo temperatures
Tanker	Cargo temperatures
chemical tanker ESP	List of cargoes intended to be carried, with their density Types of cargo to be carried in each tank Cargo temperatures Arrangement of pressure/vacuum valves in cargo tanks For ships with independent tanks, connection of the cargo tanks to the hull structure
liquefied gas carrier	Arrangement of pressure/vacuum valves in cargo tanks Heat transfer analysis Distribution of steel qualities For ships with independent tanks: • cargo tank structure • connection of the cargo tanks to the hull structure • anti-floating and anti-collision arrangements
dredger	Transverse sections through hoppers, wells, pump rooms and dredging machinery spaces Structural arrangement of hoppers and supporting structures Closing arrangements, if any Connection of dredging machinery with the hull structure
hopper dredger **hopper unit**	Transverse sections through hoppers, wells, pump rooms and dredging machinery spaces Structural arrangement of hoppers and supporting structures including: • location, mass, fore and aft extent of the movable dredging equipment, for each loading condition • calculations of the horizontal forces acting on the suction pipe and on the gallows Closing arrangements, if any Connection of dredging machinery with the hull structure

Service notations	Plans or documents
split hopper dredger **split hopper unit**	Transverse sections through hoppers, wells, pump rooms and dredging machinery spaces Structural arrangement of hoppers and supporting structures, including: • location, mass, fore and aft extent of the movable dredging equipment, for each loading condition • calculations of the horizontal forces acting on the suction pipe and on the gallows Closing arrangements, if any Connection of dredging machinery with the hull structure Superstructure hinges and connections to the ship's structure, including mass and location of the superstructure centre of gravity Structure of hydraulic jack spaces Deck hinges, including location of centre of buoyancy and of centre of gravity of each half-hull, mass of equipped half-hull, half mass of spoil or water, supplies for each half-hull and mass of superstructures supported by each half-hull Hydraulic jacks and connections to ship's structure including operating pressure and maximum pressure of the hydraulic jacks (cylinder and rod sides) and corresponding forces Longitudinal chocks of bottom and deck Transverse chocks Hydraulic installation of jacks, with explanatory note
tug **salvage tug** **tug escort**	Structural arrangement of the winch and its remote control of the quick-release device for opening under load Structural arrangement of the hook and its remote control of the quick-release device for opening under load Connection of the towing system (winch and hook) with the hull structures
tug, **salvage tug**, **tug escort** with additional service feature **barge combined** **barge** with additional service feature **tug combined**	Structural arrangement of the fore part of the tug, showing details of reinforcements in way of the connecting point Structural arrangement of the aft part of the barge, showing details of reinforcements in way of the connecting point Details of the connection system
supply vessel and **offshore support vessel**.	General plan showing the location of storage and cargo tanks with adjacent cofferdams and indicating the nature and density of cargoes intended to be carried Plan of gas-dangerous spaces Connection of the cargo tanks with the hull structure Stowage of deck cargoes and lashing arrangement with location of lashing points and indication of design loads Structural reinforcements in way of load transmitting elements, such as winches, rollers, lifting appliances
supply vessel and **offshore support vessel** with additional service feature **anchor handling** or **anchor handling stab**	General arrangement of the fittings and equipment for anchor handling operations Structural drawings of the guides/rollers used for anchor handling operations Structural drawings of hull supporting structures in way of guides/rollers used for anchor handling operations Only for ships with service feature anchor handling stab: stability operational manual for anchor handling operations, as detailed in Pt E, Ch 15, Sec 2, [3.4.3]
oil recovery ship	General plan showing the location of tanks intended for the retention of oily residues and systems for their treatment Plan of the system for treatment of oily residues and specification of all relevant apparatuses Supporting structures of the system for treatment of oily residues Operating manual
fishing vessel	Minimum design temperature of refrigerated spaces Structural reinforcements in way of load transmitting elements, such as masts, gantries, trawl gallows and winches, including the maximum brake load of the winches

Table 3 : Plans and documents to be submitted depending on additional class notations *(1/3/2008)*

Additional class notation	Plans or documents
DMS	See Pt F, Ch 13, Sec 11, [1.2]
ICE CLASS IA SUPER **ICE CLASS IA** **ICE CLASS IB** **ICE CLASS IC** **ICE CLASS ID**	The plans relevant to shell expansion and fore and aft part structures are to define (see Pt F, Ch 9, Sec 1, [2.2]) the maximum draught LWL, the minimum draught BWL (both draughts at midship, fore and aft ends), and the borderlines of fore, midship and aft regions defined in Pt F, Ch 9, Sec 2, [1.2]
LASHING	Lashing arrangement plans, indicating: • container arrangement in holds, on decks and on hatch covers, with specification of the gross mass of each container and of each container stack • arrangement of mobile lashing equipment with the specific location of the various pieces of equipment Complete list of the mobile lashing equipment, with detailed drawing and indication of materials, safety working loads, breaking loads or test loads Removable load-bearing structures for containers, such as guides, cells, buttresses, etc., connected to the hull structure or to hatch covers
MON-HULL	See Pt F, Ch 5, Sec 1, [1.2]
POLAR CLASS PC1 **POLAR CLASS PC2** **POLAR CLASS PC3** **POLAR CLASS PC4** **POLAR CLASS PC5** **POLAR CLASS PC6** **POLAR CLASS PC7**	The plans relevant to shell expansion and fore and aft part structures are to define the maximum draught at UIWL, the minimum draught at LIWL (both draughts at midship, fore and aft ends), and the borderlines of hull areas in longitudinal and vertical directions as indicated in Pt F, Ch 10, Sec 2, [1.2] as well as the other items required for the structural checks as per Pt F, Ch 10, Sec 2, [4] and Pt F, Ch 10, Sec 2, [6].
SPM	See Pt F, Ch 13, Sec 4, [2]

SECTION 4 CALCULATION PROGRAMS

1 Program for the Rule based scantling

1.1 General

1.1.1 Computer programs dealing with rule checking are available. The Society may be contacted in order to have information on these programs and associated hardware and operating system requirements.

1.2 LEONARDO HULL

1.2.1 *(1/7/2005)*
The LEONARDO HULL program performs the rule scantling check of plating and ordinary stiffeners at any transverse section along the ship's hull, primary supporting members and associated shell plating in various hull portions.

1.2.2 *(1/7/2005)*
In particular, LEONARDO HULL makes it possible to:

- calculate the transverse section geometric properties
- carry out the hull girder strength checks, including ultimate strength
- carry out all the rule strength checks of:
  - strakes
  - longitudinal and transverse ordinary stiffeners
  - strakes and ordinary stiffeners of transverse bulkheads.
- verification and finite element analysis of hull structure, including automatic generation of part of the finite element model and load case generation. Scantling criteria verification, in accordance with the Rules, are automatically performed.

1.2.3 *(1/7/2005)*
LEONARDO HULL also calculates the steel renewal thicknesses based on rule scantlings and permits the re-assessment of ships in service.

1.3 BULK

1.3.1 The BULK program is designed to assess, according to the IACS Unified Requirements adopted in the Rules, the structural strength of transverse corrugated bulkheads and double bottoms of new and existing bulk carriers to which these requirements apply.

Part B
Hull and Stability

Chapter 2
GENERAL ARRANGEMENT DESIGN

Symbols used in chapter 2

FP_{LL} : "forward freeboard perpendicular". The forward freeboard perpendicular is to be taken at the forward end the length L_{LL} and is to coincide with the foreside of the stem on the waterline on which the length L_{LL} is measured.

AP_{LL} : "after freeboard perpendicular". The after freeboard perpendicular is to be taken at the after end the length L_{LL}.

SECTION 1 SUBDIVISION ARRANGEMENT

1 Number and arrangement of transverse watertight bulkheads

1.1 Number of watertight bulkheads

1.1.1 General

All ships, in addition to complying with the requirements of [1.1.2], are to have at least the following transverse watertight bulkheads:

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

1.1.2 Additional bulkheads

For ships not required to comply with subdivision regulations, transverse bulkheads adequately spaced and in general not less in number than indicated in Tab 1 are to be fitted.

Additional bulkheads may be required for ships having to comply with subdivision or damage stability criteria (see Part E for the different types of ships).

Table 1 : Number of bulkheads

Length (m)	Number of bulkheads for ships with aft machinery **(1)**	Number of bulkheads for other ships
L < 65	3	4
65 ≤ L < 85	4	5
85 ≤ L < 105	4	5
105 ≤ L < 120	5	6
120 ≤ L < 145	6	7
145 ≤ L < 165	7	8
165 ≤ L < 190	8	9
L ≥ 190	to be defined on a case by case basis	
(1) After peak bulkhead and aft machinery bulkhead are the same.		

2 Collision bulkhead

2.1 Arrangement of collision bulkhead

2.1.1 *(1/7/2011)*

A collision bulkhead is to be fitted which is to be watertight up to the freeboard deck. This bulkhead is to be located at a distance from the forward perpendicular FP_{LL} of not less than 0,05 L_{LL} or 10 m, whichever is the less, and not more than 0,08 L_{LL} or 0,05 L_{LL} + 3 m, whichever is the greater.

2.1.2 *(1/7/2011)*

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 [2.1.1] are to be measured from a point either:

- *at the midlength of such extension, or*
- *at a distance 0,015 L_{LL} forward of the forward perpendicular, or*
- *at a distance 3 metres forward of the forward perpendicular; whichever gives the smallest measurement.*

2.1.3 *(1/7/2011)*

The bulkhead may have steps or recesses provided they are within the limits prescribed in [2.1.1] or [2.1.2].

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

2.1.4 The Society may, on a case by case basis, accept a distance from the collision bulkhead to the forward perpendicular FP_{LL} greater than the maximum specified in [2.1.1] and [2.1.2], 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 submerged, or in any unacceptable loss of stability.

2.1.5 *(1/7/2011)*

Where a long forward superstructure is fitted, the collision bulkhead is to be extended weathertight to the next deck above the freeboard deck. The extension need not be fitted directly above the bulkhead below provided it is located within the limits prescribed in [2.1.1] or [2.1.2] with the exemption permitted by [2.1.6] and that the part of the deck which forms the step is made effectively weathertight.The extension is to be so arranged as to preclude the possibility of the bow door causing damage to it in the case of damage to, or detachment of, a bow door.

2.1.6 *(1/7/2011)*

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 which is more than 2,3 m above the freeboard deck may extend forward of the limit specified in [2.1.1] or [2.1.2]. The ramp is to be weath-

ertight over its complete length. Ramps not meeting the above requirements are to be disregarded as an extension of the collision bulkhead.

2.1.7 *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 After peak, machinery space bulkheads and stern tubes

3.1

3.1.1 General

An after peak bulkhead, and bulkheads dividing the machinery space from the cargo and passenger spaces forward and aft, are also to be fitted and made watertight up to the bulkhead deck for passenger ships and to the freeboard deck for other ships. 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 diminished.

3.1.2 Sterntubes

Sterntubes are to be enclosed in a watertight space (or spaces) of moderate volume. Other measures to minimise the danger of water penetrating into the ship in case of damage to sterntube arrangements may be taken at the discretion of the Society.

For ships less than 65 m, where the after peak bulkhead in way of the sterntube stuffing box is not provided, sterntubes are to be enclosed in watertight spaces of moderate volume.

4 Number and arrangement of tank bulkheads

4.1 Bulkheads in ships intended for the carriage of liquid cargoes

4.1.1 The number and location of transverse and longitudinal watertight bulkheads in ships intended for the carriage of liquid cargoes (tankers and similar) are to comply with the subdivision requirements to which the ship is subject.

5 Height of transverse watertight bulkheads

5.1

5.1.1 Transverse watertight bulkheads other than the collision bulkhead and the after peak bulkhead are to extend watertight up to the freeboard deck. In exceptional cases at the request of the Owner, the Society may allow transverse watertight bulkheads to terminate at a deck below that from which freeboard is measured, provided that this deck is at an adequate distance above the full load waterline.

5.1.2 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.

6 Openings in watertight bulkheads and decks

6.1 General

6.1.1 *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., arrangements are to be made to maintain the watertight integrity. The Society may permit relaxation in the watertightness of openings above the freeboard deck, provided that it is demonstrated that any progressive flooding can be easily controlled and that the safety of the ship is not impaired.*

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

6.1.3 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.

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

6.1.5 *(1/7/2021)*

The cable transits seal systems in watertight bulkheads and decks are to be type approved regarding watertightness. The pressure for which these cable transits seal systems are to be certified is to be greater than or equal to the one taken for the determination of the scantlings of the structural plate where they are located.

6.1.6 The requirements relevant to the degree of tightness, as well as the operating systems, for doors or other closing appliances complying with the provisions in [6.2] and [6.3] are specified in Tab 2.

6.2 Openings in the watertight bulkheads below the freeboard deck

6.2.1 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 individual hand-operated mechanism. The possibility of opening and closing the door by hand at the door itself from both sides is to be assured.

6.2.2 Openings normally closed at sea

Access doors and access hatch covers normally closed at sea, 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. The use of such doors and hatch covers is to be authorised by the officer of the watch.

Table 2 : Doors

			Sliding type			Hinged type			Rolling type (cargo between deck spaces)
			Remote operation indication on the bridge	Indicator on the bridge	Local operation only	Remote operation indication on the bridge	Indicator on the bridge	Local operation only	
Watertight	Below the freeboard deck	Open at sea	X						
		Normally closed **(2)**		X			X **(3)**		
		Remain closed **(2)**			X **(4) (5)**			X **(4) (5)**	X **(4) (5)**
Weathertight / watertight **(1)**	Above the freeboard deck	Open at sea	X						
		Normally closed **(2)**		X			X		
		Remain closed **(2)**						X **(4) (5)**	

(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) Notice to be affixed on both sides of the door: "to be kept closed at sea".
(3) Type A ships of 150 m and upwards, and Type B ships with a reduced freeboard may have a hinged watertight door between the engine room and the steering gear space, provided that the sill of this door is above the summer load waterline.
(4) The door is to be closed before the voyage commences.
(5) If the door is accessible during the voyage, a device which prevents unauthorised opening is to be fitted.

6.2.3 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 which prevents unauthorised opening.

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

6.2.4 Openings permanently kept 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 which is to be affixed to each such closing appliance to the effect that it is to be kept closed. Manholes fitted with closely bolted covers need not be so marked.

6.3 Openings in the bulkheads above the freeboard deck

6.3.1 General

The openings in flooding boundaries located below the waterline at the equilibrium of the final stage of flooding are to be watertight. The openings immersed within the range of the positive righting lever curve are only to be weathertight.

6.3.2 Doors used while at sea

The doors used while at sea are to be sliding 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 individual hand-operated mechanism. It should be possible to open and close the door by hand at the door itself from both sides.

6.3.3 Doors normally closed at sea

The doors normally closed at sea are to be provided with means of indication locally and on the bridge showing whether these doors are open or closed. A notice is to be affixed to each door to the effect that it is not to be left open.

6.3.4 Openings kept permanently closed at sea

The doors kept closed at sea are to be hinged doors. Such doors and the other closing appliances which are kept closed at sea are to be provided with a notice affixed to each closing appliance to the effect that it is to be kept closed. Manholes fitted with closely bolted covers need not be so marked.

SECTION 2 COMPARTMENT ARRANGEMENT

1 Definitions

1.1 Cofferdam

1.1.1 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.

1.2 Machinery spaces of category A

1.2.1 *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.*

2 Cofferdams

2.1 Cofferdam arrangement

2.1.1 Cofferdams are to be provided between compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and those intended for fresh water (drinking water, water for propelling machinery and boilers) as well as tanks intended for the carriage of liquid foam for fire extinguishing.

2.1.2 Cofferdams separating fuel oil tanks from lubricating oil tanks and the latter from those intended for the carriage of liquid foam for fire extinguishing or fresh water or boiler feed water 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 thickness of common boundary plates of adjacent tanks is increased, with respect to the thickness obtained according to Ch 7, Sec 1, by 2 mm in the case of tanks carrying fresh water or boiler feed water, and by 1 mm in all other cases
- the sum of the throats 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 12, Sec 3, [2].

2.1.3 *(1/7/2021)*

Spaces intended for the carriage of flammable liquids are to be separated from accommodation and service spaces by means of a cofferdam. Where accommodation and service spaces are arranged immediately above such spaces, the cofferdam may be omitted only where the deck is not provided with access openings and is coated with a layer of material which will not give rise to smoke or toxic or explosive hazards at elevated temperatures. These properties shall be determined in accordance with the Fire Test Procedure Code for the type of coating, either primary deck covering or paint, provided.

The cofferdam may also be omitted where such spaces are adjacent to a passageway, subject to the conditions stated in [2.1.2] for fuel oil or lubricating oil tanks.

2.1.4 Cofferdams are only required between fuel oil double bottoms and tanks immediately above where the inner bottom plating is subjected to the head of fuel oil contained therein, as in the case of a double bottom with its top raised at the sides.

Where a corner to corner situation occurs, tanks are not be considered to be adjacent.

Adjacent tanks not separated by cofferdams are to have adequate dimensions to ensure easy inspection.

3 Double bottoms

3.1 General

3.1.1 Double bottom *(1/1/2024)*

a) *A double bottom shall be fitted extending from the collision bulkhead to the afterpeak bulkhead, as far as this is practicable and compatible with the design and proper working of the ship.*

b) *Where a double bottom is required to be fitted the inner bottom shall be continued out to the ship's sides in such a manner as to protect the bottom to the turn of the bilge. Such protection will be deemed satisfactory if the inner bottom is not lower at any part than a plane parallel with the keel line and which is located not less than a vertical distance h measured from the keel line, as calculated by the formula:*

   $h = B / 20$

   However, in no case is the value of h to be less than 760 mm, and need not be taken as more than 2,000 mm.

c) *Small wells constructed in the double bottom in connection with drainage arrangements, shall not extend downward more than necessary. The vertical distance from the bottom of such a well to a plane coinciding with the keel line shall not be less than h/2 or 500 mm, whichever is greater, or compliance with* *paragraph k) of this article shall be shown for that part of the ship.*

d) *Other wells (e.g. for lubricating oil under main engines) may be permitted by the Society if satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with this article.*

e) *For a cargo ship of 80 m in length and upwards or for a passenger ship, proof of equivalent protection is to be shown by demonstrating that the ship is capable of withstanding bottom damages as specified in paragraph k). Alternatively, wells for lubricating oil below main engines may protrude into the double bottom below the boundary line defined by the distance h provided that the vertical distance between the well bottom and a plane coinciding with the keel line is not less than h/2 or 500 mm, whichever is greater.*

f) *For cargo ships of less than 80 m in length the arrangements shall provide a level of safety to the satisfaction of the Society.*

g) A double bottom need not be fitted in way of watertight tanks, including dry tanks of moderate size, provided the safety of the ship is not impaired in the event of bottom or side damage.

h) *In the case of passenger ships to which the provisions of SOLAS regulation II-1/1.5 apply and which are engaged on regular service within the limits of a short international voyage as defined in SOLAS regulation III/3.22, the Society may permit a double bottom to be dispensed with if satisfied that the fitting of a double bottom in that part would not be compatible with the design and proper working of the ship.*

i) *Any part of a cargo ship of 80 m in length and upwards or of a passenger ship that is not fitted with a double bottom in accordance with paragraphs a), g) or h), as specified in paragraph b) shall be capable of withstanding bottom damages, as specified in paragraph h), in that part of the ship. For cargo ships of less than 80 m in length the alternative arrangements shall provide a level of safety to the satisfaction of the Society.*

j) *In the case of unusual bottom arrangements in a cargo ship of 80 m in length and upwards or a passenger ship, it shall be demonstrated that the ship is capable of withstanding bottom damages as specified in paragraph k). For cargo ships of less than 80 m in length the alternative arrangements shall provide a level of safety to the satisfaction of the Society.*

k) *Compliance with paragraphs c), e), i) or j) is to be achieved by demonstrating that si, when calculated in accordance with SOLAS regulation II-1/7-2, is not less than 1 for all service conditions when subject to a bottom damage assumed at any position along the ship's bottom and with an extent specified in 2) below for any position in the affected part of the ship:*

1) *Flooding of such spaces shall not render emergency power and lighting, internal communication, signals or other emergency devices inoperable in other parts of the ship.*

2) *Assumed extent of damage shall be as in* Tab 1.

3) *If any damage of a lesser extent than the maximum damage specified in 2) would result in a more severe condition, such damage should be considered.*

l) *In case of large lower holds in passenger ships, the Administration may require an increased double bottom height of not more than B/10 or 3 m, whichever is less, measured from the keel line. Alternatively, bottom damages may be calculated for these areas, in accordance with paragraph k), but assuming an increased vertical extent.*

For ships not subject to SOLAS Convention the requirements of this item [3.1.1] will be specially considered by the Society in each single case.

3.1.2 *(1/1/2011)*

Special requirements for tankers are specified in Part E.

Table 1 *(1/1/2011)*

	For 0,3 L from the forward perpendicular of the ship	Any other part of the ship
Longitudinal extent	1/3 $L^{2/3}$ or 14.5 m, whichever is less	1/3 $L^{2/3}$ or 14.5 m, whichever is less
Transverse extent	B/6 or 10 m, whichever is less	B/6 or 5 m, whichever is less
Vertical extent, measured from the keel line	B/20 or 2 m, whichever is less	B/20 or 2 m, whichever is less

4 Compartments forward of the collision bulkhead

4.1 General

4.1.1 The fore peak and other compartments located forward of the collision bulkhead may not be arranged for the carriage of fuel oil or other flammable products.

This requirement does not apply to ships of less than 400 tons gross tonnage, except for those where the fore peak is the forward cofferdam of tanks arranged for the carriage of flammable liquid products having a flash point not exceeding 60°C.

5 Minimum bow height

5.1 Application

5.1.1 *(1/7/2008)*

This item [5] applies to ships subject to the International Load Line Convention 1966, as amended.

paragraph k) of this article shall be shown for that part of the ship.

d) *Other wells (e.g. for lubricating oil under main engines) may be permitted by the Society if satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with this article.*

e) *For a cargo ship of 80 m in length and upwards or for a passenger ship, proof of equivalent protection is to be shown by demonstrating that the ship is capable of withstanding bottom damages as specified in paragraph k). Alternatively, wells for lubricating oil below main engines may protrude into the double bottom below the boundary line defined by the distance h provided that the vertical distance between the well bottom and a plane coinciding with the keel line is not less than h/2 or 500 mm, whichever is greater.*

f) *For cargo ships of less than 80 m in length the arrangements shall provide a level of safety to the satisfaction of the Society.*

g) A double bottom need not be fitted in way of watertight tanks, including dry tanks of moderate size, provided the safety of the ship is not impaired in the event of bottom or side damage.

h) *In the case of passenger ships to which the provisions of SOLAS regulation II-1/1.5 apply and which are engaged on regular service within the limits of a short international voyage as defined in SOLAS regulation III/3.22, the Society may permit a double bottom to be dispensed with if satisfied that the fitting of a double bottom in that part would not be compatible with the design and proper working of the ship.*

i) *Any part of a cargo ship of 80 m in length and upwards or of a passenger ship that is not fitted with a double bottom in accordance with paragraphs a), g) or h), as specified in paragraph b) shall be capable of withstanding bottom damages, as specified in paragraph h), in that part of the ship. For cargo ships of less than 80 m in length the alternative arrangements shall provide a level of safety to the satisfaction of the Society.*

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k) *Compliance with paragraphs c), e), i) or j) is to be achieved by demonstrating that si, when calculated in accordance with SOLAS regulation II-1/7-2, is not less than 1 for all service conditions when subject to a bottom damage assumed at any position along the ship's bottom and with an extent specified in 2) below for any position in the affected part of the ship:*

1) *Flooding of such spaces shall not render emergency power and lighting, internal communication, signals or other emergency devices inoperable in other parts of the ship.*
2) *Assumed extent of damage shall be as in* Tab 1.
3) *If any damage of a lesser extent than the maximum damage specified in 2) would result in a more severe condition, such damage should be considered.*

l) *In case of large lower holds in passenger ships, the Administration may require an increased double bottom height of not more than B/10 or 3 m, whichever is less, measured from the keel line. Alternatively, bottom damages may be calculated for these areas, in accordance with paragraph k), but assuming an increased vertical extent.*

For ships not subject to SOLAS Convention the requirements of this item [3.1.1] will be specially considered by the Society in each single case.

3.1.2 *(1/1/2011)*

Special requirements for tankers are specified in Part E.

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	For 0,3 L from the forward perpendicular of the ship	Any other part of the ship
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Transverse extent	B/6 or 10 m, whichever is less	B/6 or 5 m, whichever is less
Vertical extent, measured from the keel line	B/20 or 2 m, whichever is less	B/20 or 2 m, whichever is less

4 Compartments forward of the collision bulkhead

4.1 General

4.1.1 The fore peak and other compartments located forward of the collision bulkhead may not be arranged for the carriage of fuel oil or other flammable products.

This requirement does not apply to ships of less than 400 tons gross tonnage, except for those where the fore peak is the forward cofferdam of tanks arranged for the carriage of flammable liquid products having a flash point not exceeding 60°C.

5 Minimum bow height

5.1 Application

5.1.1 *(1/7/2008)*

This item [5] applies to ships subject to the International Load Line Convention 1966, as amended.

5.2 General

5.2.1 *(1/7/2011)*

In all ships which are subject to the provisions of the International Convention on Load Line in force, the bow height F_b, defined as the vertical distance at the forward perpendicular between the waterline corresponding to the assigned summer freeboard at the designed trim and the top of the exposed deck at side, is to be not less than:

$F_b = (6075(L_{LL}/100) - 1875(L_{LL}/100)^2 + 200(L_{LL}/100)^3) \cdot (2{,}08 + 0{,}609C_b - 1{,}603C_{wf} - 0{,}0129(L_{LL}/T_1))$

where:

- F_b : *calculated minimum bow height, in mm*
- T_1 : *draught at 85% of the least moulded depth D_1, in m*
- ∇ D_1 : *least moulded depth, in m, to be taken as the least vertical distance measured from the top of the keel to the top of the freeboard deck beam at side. Where the form at the lower part of the midship section is of a hollow character, or where thick garboards are fitted, the vertical distance is to be measured from the point where the line of the flat of the bottom continued inwards cuts the side of the keel. In ships having rounded gunwales, the vertical distance is to be measured to the point of intersection of the moulded lines of deck and sides, the lines extending as though the gunwale were of angular design. Where the freeboard deck is stepped and the raised part of the deck extends over the point at which the moulded depth is to be determined, the vertical distance is to be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.*
- C_b : *block coefficient:*

$$C_b = \frac{\nabla}{L_{LL} B T_1}$$

- : *volume of the moulded displacement, excluding appendages, in m^3, at draught T_1*
- C_{wf} : *waterplane area coefficient forward of $L_{LL}/2$:*

$$C_{wf} = \frac{A_{wf}}{\frac{L_{LL}}{2} B}$$

- A_{wf} : *waterplane area forward of $L_{LL}/2$ at draught T_1, in m^2.*

For ships to which timber freeboards are assigned, the summer freeboard (and not the timber summer freeboard) is to be assumed when applying the formula above.

5.2.2 *(1/1/2005)*

Where the bow height required in item [5.2.1] is obtained by sheer, the sheer is to extend for at least 15% of the length of the ship measured from the forward perpendicular. Where it is obtained by fitting a superstructure, such superstructure is to extend from the stem to a point at least 0,07L abaft the forward perpendicular, and is to be enclosed as defined Ch 9, Sec 4.

5.2.3 *(1/1/2005)*

Ships which, to suit exceptional operational requirements, cannot meet the requirements in [5.2.1] and [5.2.2] are considered by the Society on a case-by-case basis.

5.2.4 *(1/1/2005)*

The sheer of the forecastle deck may be taken into account, even if the length of the forecastle is less than 0,15L, but greater than 0,07L, provided that the forecastle height is not less than one half of the standard height of superstructure between 0,07L and the forward perpendicular.

5.2.5 *(1/1/2005)*

Where the forecastle height is less than one half of the standard height of superstructure, the credited bow height may be determined as follows (h_f in Fig 1 and Fig 2 is one half of the standard height of superstructure):

a) *Where the freeboard deck has sheer extending from abaft 0,15L, by a parabolic curve having its origin at 0,15L abaft the forward perpendicular at a height equal to the midship depth of the ship, extended through the point of intersection of forecastle bulkhead and deck, and up to a point at the forward perpendicular not higher than the level of the forecastle deck (as illustrated in Fig 1). However, if the value of the height denoted h_t in Fig 1 is smaller than the value of the height denoted h_b then h_t may be replaced by h_b in the available bow height, where:*

$$h_t = Z_b \left(\frac{0{,}15L}{x_b}\right)^2 - Z_t$$

- Z_b : *as defined in Fig 1*
- Z_t : *as defined in Fig 1*

b) *Where the freeboard deck has sheer extending for less than 0,15L or has no sheer, by a line from the forecastle deck at side at 0,07L extended parallel to the base line to the forward perpendicular (as illustrated in Fig 2).*

5.2.6 *(1/1/2005)*

All ships assigned a type 'B' freeboard are to have additional reserve buoyancy in the fore end. Within the range of 0,15L abaft the forward perpendicular, the sum of the projected area between the summer load waterline and the deck at side (A1 and A2 in Fig 3) and the projected area of an enclosed superstructure, if fitted, (A3 in Fig 3) is not to be less than:

$[0.15F_{min} + 4(L_{LL}/3 + 10)]\, L_{LL}/1000$, in m^2,

where:

- F_{min} : *coefficient, to be taken equal to:*

  $F_{min} = (F_0\, f_1) + f_2$
- F_0 : *is the tabular freeboard, in mm, taken from the International Convention Load Line in force, table 28.2, corrected for regulation 27(9) or 27(10), as applicable*
- f_1 : *is the correction for block coefficient given in the International Convention Load Line in force, regulation 30, and*
- f_2 : *is the correction for depth, in mm, given in the International Convention Load Line in force, regulation 31.*

Figure 1 : Credited bow height where the freeboard deck has sheer extending from abaft 0,15L *(1/1/2005)*

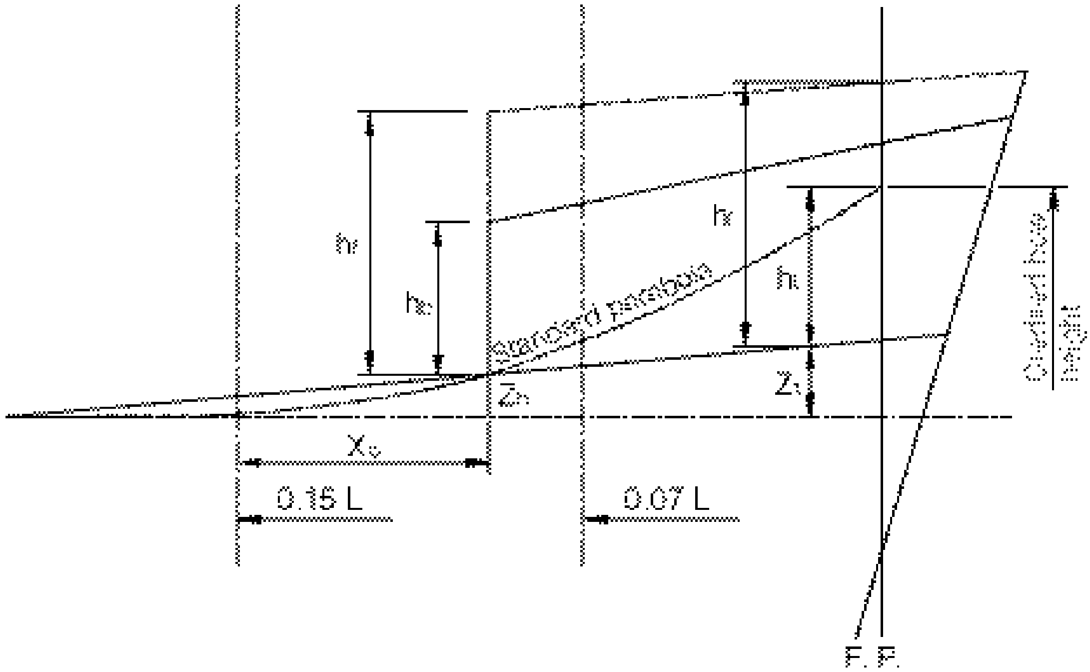


Figure 2 : Credited bow height where the freeboard deck has sheer extending for less than 0,15L *(1/1/2005)*

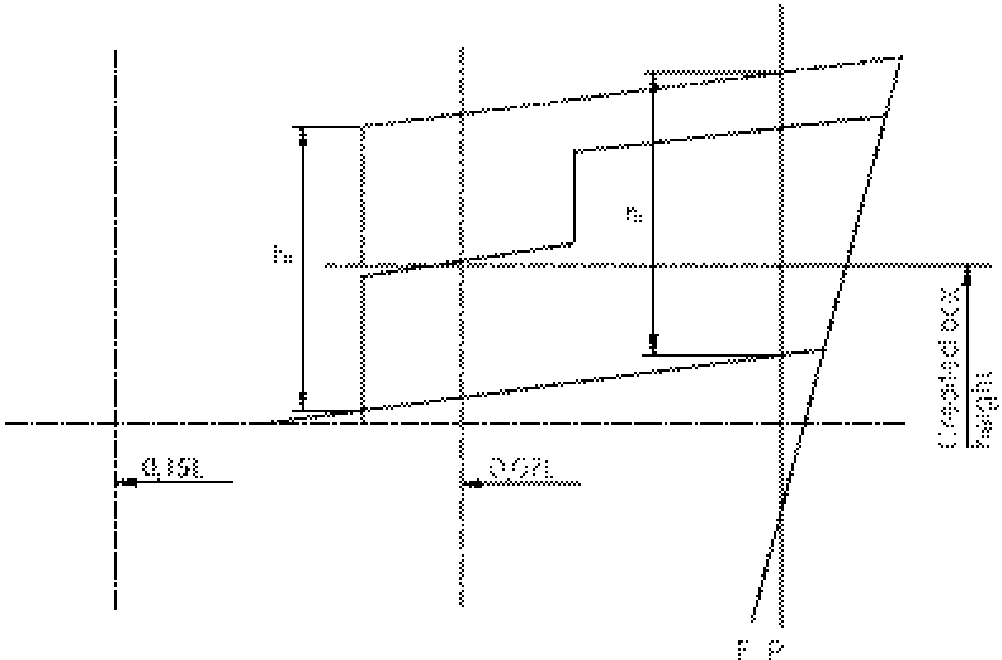
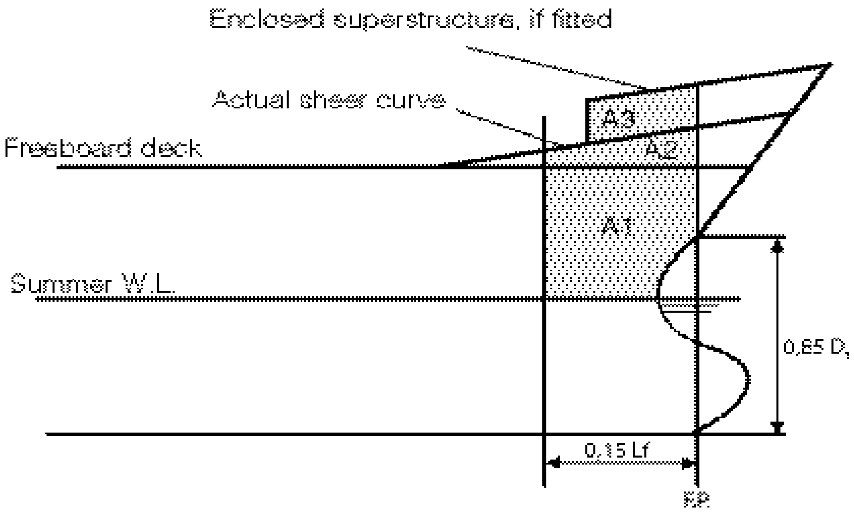


Figure 3 : Areas A1, A2 and A3 *(1/7/2011)*



6 Shaft tunnels

6.1 General

6.1.1 Shaft tunnels are to be watertight.

See also Sec 3, [4].

7 Watertight ventilators and trunks

7.1 General

7.1.1 *Watertight ventilators and trunks are to be carried at least up to the bulkhead deck in passenger ships and up to the freeboard deck in ships other than passenger ships.*

8 Fuel oil tanks

8.1 General

8.1.1 *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.*

8.1.2 *As far as practicable, fuel oil tanks are to be part of the ship's structure and are to be located outside machinery spaces of category A.*

Where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of category A, at least one of their vertical sides is to be contiguous to the machinery space boundaries, 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 situated within the boundaries of machinery spaces of category A, they may not contain fuel oil having a flashpoint of less than 60°C.

8.1.3 *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.

8.1.4 Where a compartment intended for goods or coal is situated in proximity of a heated liquid container, suitable thermal insulation is to be provided.

SECTION 3 ACCESS ARRANGEMENT

1 General

1.1

1.1.1 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 satisfactory operation of the ship.

2 Double bottom

2.1 Inner bottom manholes

2.1.1 Inner bottom manholes are to be not less 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.

2.1.2 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 by the cargo.

2.2 Floor and girder manholes

2.2.1 Manholes are to be provided in floors and girders so as to provide convenient access to all parts of the double bottom.

2.2.2 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 sizes are needed, edge reinforcement by means of flat bar rings or other suitable stiffeners may be required.

2.2.3 Manholes may not be cut into the continuous centreline girder or floors and girders below pillars, except where allowed by the Society on a case by case basis.

3 Large cargo holds, large tanks and large water ballast tanks

3.1 General

3.1.1 Tanks in double bottom and in double side are generally not to be considered as large water ballast tanks.

3.2 Access to tanks

3.2.1 Tanks with a length equal or greater than 35 m

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.

3.2.2 Tanks with a length less than 35 m

Tanks less than 35 m in length are to be served by at least one access hatchway and ladder.

3.2.3 Dimensions of access hatchways

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.

3.2.4 Tanks subdivided by wash bulkheads

When a tank is subdivided by one or more wash 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.

3.3 Access within tanks

3.3.1 Wash bulkheads in tanks

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

3.3.2 Passage on the tank bottom

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.

3.3.3 Passageways in the tanks

a) *Passageways in the tanks 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's 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.*

3.3.4 Manholes

Where manholes are fitted, as indicated in [2.2.2], access is to be facilitated by means of steps and hand grips with platform landings on each side.

3.3.5 Guard rails

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.

3.4 Construction of ladders

3.4.1 General

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.

3.4.2 Construction

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.

3.4.3 Corrosive effect of the cargo

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

3.4.4 Width of ladders

The width of ladders between stringers is not to be less than 400 mm.

3.4.5 Treads

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.

3.4.6 Sloping ladders

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

4 Shaft tunnels

4.1 General

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

4.1.2 Access to the tunnel is to be provided by a watertight door fitted on the aft bulkhead of the engine room in compliance with Sec 1, [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 Access to steering gear compartment

5.1

5.1.1 The steering gear compartment is to be readily accessible and, as far as practicable, separated from machinery spaces.

5.1.2 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.

Part B
Hull and Stability

Chapter 3
STABILITY

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 General

All ships equal to or greater than 24 m in length may be assigned class only after it has been demonstrated that their intact stability is adequate for the service intended. Adequate intact stability means compliance with standards laid down by the relevant Administration or with the requirements specified in this Chapter taking into account the ship's size and type. In any case, the level of intact stability is not to be less than that provided by the Rules.

1.1.2 Ships less than 24 m in length

The Rules also apply to ships less than 24 m in length. In this case, the requirements concerned may be partially omitted subject to the agreement of the Society.

1.1.3 Approval of the Administration *(1/7/2003)*

When the Administration of the State whose flag the ship is entitled to fly has issued specific rules covering stability, the Society may accept such rules for classification purposes in lieu of those given in this Chapter.

Evidence of approval of the stability by the Administration concerned may be accepted for the purpose of classification.

In cases of application of the above requirements an appropriate entry is made in the classification files of the ship.

2 Definitions

2.1 General

2.1.1 *(1/7/2010)*

For the purpose of this Chapter 3 the definitions given in the International Code on Intact Stability, 2008 (IMO Resolution MSC.267(85)) apply. The definitions in [2.2] to [2.7] are given for ease of reference.

2.2 Length of ship

2.2.1 *(1/7/2010)*

The length is to be taken as 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or as the length from the foreside of the stem to the axis of the rudder stock on the waterline, if that is greater. In ships designed with a rake of keel, the waterline on which this length is measured is to be parallel to the designed waterline.

2.3 Moulded breadth

2.3.1 *(1/7/2010)*

The moulded breadth is the maximum breadth of the ship measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material.

2.4 Moulded depth

2.4.1 *(1/7/2010)*

The moulded depth is the vertical distance measured from the top of the keel to the top of the freeboard deck beam at side. In wood and composite ships, the distance is measured from the lower edge of the keel rabbet. Where the form at the lower part of the midship section is of a hollow character, or where thick garboards are fitted, the distance is measured from the point where the line of the flat of the bottom continued inwards cuts the side of the keel. In ships having rounded gunwales, the moulded depth is to be measured to the point of intersection of the moulded lines of the deck and side shell plating, the lines extending as though the gunwale were of angular design. Where the freeboard deck is stepped and the raised part of the deck extends over the point at which the moulded depth is to be determined, the moulded depth is to be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.

2.5 Timber

2.5.1 *(1/7/2010)*

Timber means sawn wood or lumber, cants, logs, poles, pulpwood and all other types of timber in loose or packaged forms. The term does not include wood pulp or similar cargo.

2.6 Timber deck cargo

2.6.1 *(1/7/2010)*

Timber deck cargo means a cargo of timber carried on an uncovered part of a freeboard or superstructure deck. The term does not include wood pulp or similar cargo.

2.7 Timber load line

2.7.1 *(1/7/2010)*

Timber load line means a special load line assigned to ships complying with certain conditions related to their construction set out in the International Convention on Load Lines 1966, as amended, and used when the cargo complies with the stowage and securing conditions of the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 2011 (IMO Resolution A.1048(27)).

3 Examination procedure

3.1 Documents to be submitted

3.1.1 List of documents *(1/10/2005)*

For the purpose of the examination of the stability, the documentation listed in Ch 1, Sec 3, [1.1.2] is to be submitted for information.

The stability documentation to be submitted for approval is as follows:

a) Inclining test report for the ship, as required in [3.2] or:
   - where the stability data is based on a sister ship, the inclining test report of that sister ship along with the lightship measurement report for the ship in question; or
   - where lightship particulars are determined by methods other than inclining of the ship or its sister, the lightship measurement report of the ship along with a summary of the method used to determine those particulars as indicated in [3.2.4].

b) trim and stability booklet, as required in Sec 2, [1.1.1]

c) and, as applicable:
   - grain loading manual, as required in Pt E, Ch 4, Sec 3, [2.2.2]
   - loading computer documentation, as required in Sec 2, [1.1.2] and in Pt F, Ch 13, Sec 11, [2.1.2].

A copy of the trim and stability booklet and, if applicable, the grain stability booklet or the loading computer documentation is to be available on board for the attention of the Master.

3.1.2 Provisional documentation

The Society reserves the right to accept or demand the submission of provisional stability documentation for examination.

Provisional stability documentation includes loading conditions based on estimated lightship values.

3.1.3 Final documentation

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

When provisional stability documentation has already been submitted and the difference between the estimated values of the lightship and those obtained after completion of the test is less than:

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

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

3.2 Inclining test/lightweight check

3.2.1 Definitions

a) Lightship

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

b) Inclining test

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

c) Lightweight check

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

3.2.2 General *(1/1/2009)*

Any ship for which a stability investigation is requested in order to comply with class requirements is to be initially subject to an inclining test permitting the evaluation of the position of the lightship centre of gravity so that the stability data can be determined.

The inclining test or lightweight check (see [3.2.4]) is to be attended by a Surveyor of the Society. The Society may accept inclining tests or lightweight checks attended by a member of the flag Administration.

For cargo ships having length less than 24 metres, irrespective of their navigation, at the discretion of the Society, instead of the inclining test one or more practical stability test(s) relevant to the most severe conditions foreseen in real service may be carried out.

In such cases a report is to be prepared relevant to the tested loading conditions containing restrictions in the loading conditions and/or in ballasting, if any, which, duly approved by the Society, is to replace the prescribed stability booklet.

3.2.3 Inclining test *(1/7/2019)*

The inclining test is required in the following cases:

- Any new passenger ship regardless of size and any new cargo ship having length of 24 m and upwards, after its completion, except for the cases specified in [3.2.4]
- Any ship, if deemed necessary by the Society, where any alterations are made so as to materially affect the stabil-

ity. For a ship in service which undergoes alterations with calculable differences in lightship properties which materially affect the stability information supplied to the master, an inclining test can be avoided if:

- the deviation of lightship displacement does not exceed 2% of the original approved lightweight or 2 tonnes, whichever is greater; and
- the deviation of lightship longitudinal centre of gravity from the original does not exceed 1% of the LBP of the ship.

Where the deviation exceeds both or one of the above limits, an inclining test is to be carried out.

Where a ship is within both the above limits, even if the inclining test can be avoided, the calculated values of lightweight, lightship LCG and lightship VCG are to be used in all subsequent stability information supplied to the master.

3.2.4 Lightweight check *(1/7/2013)*

The Society may allow a lightweight check to be carried out in lieu of an inclining test in one of the following cases:

a) an individual cargo ship, provided basic stability data are available from the inclining test of a sister ship and a lightweight check is performed in order to prove that the sister ship corresponds to the prototype ship. The lightweight check is to be carried out upon the ship's completion. The final stability data to be considered for the sister ship in terms of displacement and position of the centre of gravity are those of the prototype. Whenever, in comparison with the data derived from the prototype, a deviation from the lightship displacement exceeding 1% for ships of 160 m or more in length, or 2% for ships of 50 m or less in length, or as determined by linear interpolation for intermediate lengths, or a deviation from the lightship longitudinal centre of gravity exceeding 0,5% of L_s is found, the ship is to be inclined;

b) barges and pontoons without superstructures, not subject to SOLAS Convention, provided that the vertical centre of gravity is considered at the level of the deck;

c) barges and pontoons with superstructures, not subject to the SOLAS Convention, provided that the vertical centre of gravity is assumed at a position considered suitable by the Society on the basis of the ship's geometry;

d) other ship types, not subject to SOLAS Convention and for which the execution of an inclining test may not be feasible, provided that a detailed list of weights and the positions of their centres of gravity is submitted. The correctness of the estimated values will be checked on the basis of the results of the lightweight check.

3.2.5 Detailed procedure

A detailed procedure for conducting an inclining test is included in App 1. For the lightweight check, the same procedure applies except as provided for in App 1, [1.1.8].

SECTION 2 INTACT STABILITY

1 General

1.1 Information for the Master

1.1.1 Stability booklet *(1/7/2010)*

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

If a stability instrument is used as a supplement to the stability booklet for the purpose of determining compliance with the relevant stability criteria such instrument is to be subject to approval by the Society (see Ch 11, Sec 2, [4.5]).

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

Stability data and associated plans are to be drawn up in the working language of the ship and any other language the Administration the flag of which the ship is entitled to fly may require.

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

If curves or tables of minimum operational metacentric height (GM) or maximum centre of gravity (VCG) are used to ensure compliance with the relevant intact stability criteria those limiting curves are to extend over the full range of operational trims, unless the Society agrees that trim effects are not significant. When curves or tables of minimum operational metacentric height (GM) or maximum centre of gravity (VCG) versus draught covering the operational trims are not available, the Master is to verify that the operating condition does not deviate from a studied loading condition, or verify by calculation that the stability criteria are satisfied for this loading condition taking into account trim effects.

1.1.2 Loading instrument *(1/7/2010)*

As a supplement to the approved stability booklet, a loading instrument, approved by the Society, may be used to facilitate the stability calculations mentioned in App 2.

A simple and straightforward instruction manual is to be provided.

In order to validate the proper functioning of the computer software, pre-defined loading conditions are to be run in the loading instrument periodically, at least at every periodical class survey, and the print-out is to be maintained on board as check conditions for future reference in addition to the approved test conditions booklet.

The procedure to be followed, as well as the list of technical details to be sent in order to obtain loading instrument approval, are given in Ch 11, Sec 2, [4].

1.1.3 Operating booklets for certain ships *(1/7/2010)*

Special purpose ships and novel craft are to be provided with additional information in the stability booklet such as design limitations, maximum speed, worst intended weather conditions or other information regarding the handling of the craft that the Master needs to operate the ship safely.

1.2 Permanent ballast

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

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

1.3 Still waters

1.3.1 *(1/7/2003)*

Still waters are, generally, sheets of water within a mile of the shore, distinguished by a wind scale not higher than 2 Beaufort, light breeze 4-6 knots, sea scale 2 (slight sea), mean height of waves 0,10-0,50 m.

2 Design criteria

2.1 General intact stability criteria

2.1.1 General *(1/7/2010)*

The intact stability criteria specified in [2.1.2], [2.1.3], [2.1.4] and [2.1.5] are to be complied with for the loading conditions mentioned in App 2, [1.2].

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

These criteria set minimum values, but no maximum values are recommended. It is advisable to avoid excessive values of metacentric height, since these might lead to acceleration forces which could be prejudicial to the ship, its equipment and to safe carriage of the cargo.

For ships of length less than 24 m, except passenger ships, and ships of any length classed to sail in still waters, instead of the stability criteria specified in [2.1.2], [2.1.3] and [2.1.4], only the criterion mentioned in [2.1.5] b) is to be complied with.

Where anti-rolling devices are installed in a ship, the Society is to be satisfied that the criteria can be maintained when the devices are in operation and that failure of the power supply or the failure of the device(s) will not result in the vessel being unable to meet the relevant provisions of this Chapter.

2.1.2 GZ curve area

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

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

2.1.3 Minimum righting lever

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

2.1.4 Angle of maximum righting lever *(1/7/2010)*

The maximum righting lever is to occur at an angle of heel not less than 25°. If this is not practicable, alternative criteria, based on an equivalent level of safety, may be applied subject to the approval of the Society.

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

In cases of ships with a particular design, the Society may accept an angle of heel θ_{max} less than 25° but in no case less than 15°, provided that the area "A" below the righting lever curve is not less than the value obtained, in m.rad, from the following formula:

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

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

2.1.5 Initial metacentric height *(1/7/2003)*

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

b) For ships of length less than 24 m, except passenger ships, and ships of any lenght classed to sail in still waters, the initial metacentric height GMo is not to be less than 0,35 m, except in the lightship condition.

2.1.6 Elements affecting stability *(1/7/2010)*

A number of influences such as icing of topsides, water trapped on deck, etc., adversely affect stability and are to be taken into account, so far as is deemed necessary by the Society.

2.1.7 Elements reducing stability

Provisions are to be made for a safe margin of stability at all stages of the voyage, regard being given to additions of weight, such as those due to absorption of water and icing (details regarding ice accretion are given in [6]) and to losses of weight such as those due to consumption of fuel and stores.

3 Severe wind and rolling criterion (weather criterion)

3.1 Scope

3.1.1 *This criterion supplements the stability criteria given in [2.1] for ships of 24 m in length and over. The more stringent criteria of [2.1] and the weather criterion are to govern the minimum requirements.*

3.2 Weather criterion

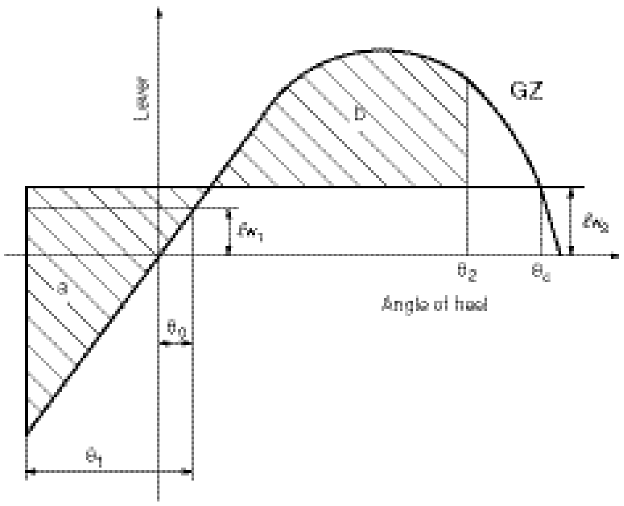
3.2.1 Assumptions *(1/7/2010)*

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

- *the ship is subjected to a steady wind pressure acting perpendicular to the ship's centreline which results in a steady wind heeling lever (ℓ_{w1});*
- *from the resultant angle of equilibrium (θ_0), the ship is assumed to roll owing to wave action to an angle of roll (θ_1) to windward. The angle of heel under action of steady wind (θ_0) is not to exceed 16° or 80% of the angle of deck edge immersion, whichever is less;*
- *the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever (ℓ_{w2});*
- *under these circumstances, area b is to be equal to or greater than area a, as indicated in Fig 1, where the angles in Fig 1 are defined as follows:*
  - θ_0 : *Angle of heel, in degrees, under action of steady wind*
  - θ_1 : *Angle of roll, in degrees, to windward due to wave action, calculated according to [3.2.4]*
  - θ_2 : *Angle of downflooding (θ_f) in degrees, or 50° or θ_c, whichever is less*

  where:
    - θ_f : *Angle of heel in degrees, at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open;*
    - θ_c : *Angle in degrees, of second intercept between wind heeling lever ℓ_{w2} and GZ curves*

Figure 1 : Severe wind and rolling *(1/7/2010)*



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

b: area above the heeling lever ℓ_{w2} and below the GZ curve, between the intersection of ℓ_{w2} with the GZ curve and ℓ_2.

3.2.2 Heeling levers *(1/7/2011)*

The wind heeling levers ℓ_{w1} and ℓ_{w2}, in m, referred to in [3.2.1], are constant values at all angles of inclination and are to be calculated as follows:

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

and

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

where:

- *P* : *wind pressure of 504 N/m². The value of P used for ships with restricted navigation notation may be reduced subject to the approval of the Society;*
- *A* : *Projected lateral area in m², of the portion of the ship and deck cargo above the waterline;*
- *Z* : *Vertical distance in m, from the centre of A to the centre of the underwater lateral area or approximately to a point at one half the mean draught;*
- *Δ* : *Displacement, in t;*
- *g* : *gravitational acceleration of 9,81 m/s².*

3.2.3 Alternative criteria *(1/7/2010)*

Alternative means for determining the wind heeling lever (ℓ_{w1}) may be accepted, to the satisfaction of the Society, as equivalent to the calculation in [3.2.2]*. When such alternative tests are carried out, reference is to be to MSC/Circ. 1200 "Interim Guidelines for alternative assessment of the weather criterion". The wind velocity used in the tests is to be 26 m/s in full scale with uniform velocity profile. The value of wind velocity used for ships engaged in restricted services may be reduced to the satisfaction of the Society.*

3.2.4 Angles of roll *(1/7/2010)*

The angle of roll θ_1, in degrees, (see Note 1*) referred to in [3.2.1] is to be calculated as follows:*

$$\theta_1 = 109 k X_1 X_2 \sqrt{rs}$$

where:

- *X_1* : *Coefficient defined in Tab 1*
- *X_2* : *Coefficient defined in Tab 2*
- *k* : *Coefficient:*
  - *k = 1,0 for a round-bilged ship having no bilge or bar keels*
  - *k = 0,7 for a ship having sharp bilge*
  - *k = as shown in Tab 3 for a ship having bilge keels, a bar keel or both.*

$$r = 0{,}73 + 0{,}6(OG)/d$$

with:

- *OG* : *KG - d*
- *KG* : *Height of centre of gravity above baseline, in m*
- *d* : *Mean moulded draught of the ship, in m*
- *s* : *Factor defined in Tab 4, where T is the ship roll natural period, in s. In absence of sufficient information, the following formula can be used:*

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

where:

$$C = 0{,}373 + 0{,}023\left(\frac{B}{d}\right) - 0{,}043\left(\frac{L_{Wl}}{100}\right)$$

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

- *$L_{w\ell}$* : *Length of the ship at the waterline, in m*
- *b* : *Moulded breadth of ship, in m*
- *d* : *Mean moulded draught of the ship, in m*
- *C_b* : *Block coefficient*
- *A_K* : *Total overall area of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas, or area of the lateral projection of any hull appendages generating added mass during ship roll, in m²*
- *GM* : *Metacentric height corrected for free surface effect, in m.*

Note 1: The angle of roll for ships with anti-rolling devices is to be determined without taking into account the operation of these devices unless the Society is satisfied with the proof that the devices are effective even with sudden shutdown of their supplied power.

3.2.5 Application criteria *(1/7/2010)*

Tables and formulae above are based on data from ships having:

- *B/d smaller than 3,5*
- *(KG/d-1) between -0,3 and 0,5*
- *T smaller than 20 s.*

For ships with parameters outside of the above limits the angle of roll (θ_1) may be determined with model experiments of a subject ship with the procedure described in MSC.1/Circ. 1200 "Interim Guidelines for alternative assessment of the weather criterion" as the alternative. In addition, the Society may accept such alternative determinations for any ship, if deemed appropriate.

4 Effects of free surfaces of liquids in tanks

4.1 General

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

4.2 Consideration of free surface effects

4.2.1 *(1/7/2010)*

Free surface effects are to be considered whenever the filling level in a tank is less than 98% of full condition. Free surface effects need not be considered where a tank is nominally full, i.e. filling level is 98% or above. However, nominally full cargo tanks are to be corrected for free surface effects at 98% filling level. In doing so, the correction to initial metacentric height is to be based on the inertia moment of liquid surface at 5° of heeling angle divided by displacement, and the correction to righting lever is to be in general on the basis of real shifting moment of cargo liquids.

4.2.2 *(1/7/2010)*

Free surface effects for small tanks may be ignored under the condition in [4.8.1].

Table 1 : Values of coefficient X_1 (1/7/2010)

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

Table 2 : Values of coefficient X_2 (1/7/2010)

C_B	X_2
≤ 0,45	0,75
0,50	0,82
0,55	0,89
0,60	0,95
0,65	0,97
≥ 0,70	1,00

Table 3 : Values of coefficient k (1/7/2010)

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

Table 4 : Values of factor s (1/7/2010)

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

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

4.3 Categories of tanks

4.3.1 *Tanks which are taken into consideration when determining the free surface correction may be one of two categories:*

- *Tanks with fixed filling level (e.g. liquid cargo, water ballast). The free surface correction is to be defined for the actual filling level to be used in each tank.*
- *Tanks with variable filling level (e.g. consumable liquids such as fuel oil, diesel oil, and fresh water, and also liquid cargo and water ballast during liquid transfer operations). Except as permitted in [4.5.1] and [4.6.1], the free surface correction is to be the maximum value attainable among the filling limits envisaged for each tank, consistent with any operating instructions.*

4.4 Consumable liquids

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

4.5 Water ballast tanks

4.5.1 *Where water ballast tanks, including anti-rolling tanks and anti-heeling tanks, are to be filled or discharged during the course of a voyage, the free surfaces effect is to be calculated to take account of the most onerous transitory stage relating to such operations.*

4.6 Liquid transfer operations

4.6.1 *(1/7/2010)*

For ships engaged in liquid transfer operations, the free surface corrections at any stage of the liquid transfer operations may be determined in accordance with the filling level in each tank at the stage of the transfer operation.

Note 1: A sufficient number of loading conditions representing the initial, intermediate and final stages of the filling or discharge operation using the free surface correction at the filling level in each tank at the considered stage may be evaluated to fulfil this recommendation.

4.7 GM_0 and GZ curve corrections

4.7.1 *The corrections to the initial metacentric height and to the righting lever curve are to be addressed separately as indicated in [4.7.2] and [4.7.3].*

4.7.2 *In determining the correction to the initial metacentric height, the transverse moments of inertia of the tanks are to be calculated at 0 degrees angle of heel according to the categories indicated in [4.3.1].*

4.7.3 *(1/7/2010)*

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

- *Correction based on the actual moment of fluid transfer for each angle of heel calculated;*
- *Correction based on the moment of inertia, calculated at 0 degrees angle of heel, modified at each angle of heel calculated.*

Corrections may be calculated according to the categories indicated in [4.2.1].

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

4.8 Small tanks

4.8.1 *(1/7/2010)*

Small tanks which satisfy the following condition corresponding to an angle of inclination of 30° need not be included in the correction:

$$M_{fs} / \Delta_{min} < 0{,}01 \text{ m}$$

where:

M_{fs} : *Free surface moment, in m*

Δ_{min} : *Minimum ship displacement, in t, calculated at d_{min}*

d_{min} : *Minimum mean service draught, in m, of ship without cargo, with 10% stores and minimum water ballast, if required.*

4.9 Remainder of liquid

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

5 Cargo ships carrying timber deck cargoes

5.1 Application

5.1.1 *(1/7/2010)*

The provisions given hereunder apply to all ships of 24 m in length and over engaged in the carriage of timber deck cargoes. Ships that are provided with and make use of their timber load line are also to comply with the requirements of regulations 41 to 45 of the International Load Line Convention 1966, as amended.

5.2 Stability criteria

5.2.1 *For ships loaded with timber deck cargoes and provided that the cargo extends longitudinally between superstructures (where there is no limiting superstructure at the after end, the timber deck cargo is to extend at least to the after end of the aftermost hatchway) and transversely for the full beam of ship after due allowance for a rounded gunwale not exceeding 4% of the breadth of the ship and/or securing the supporting uprights and which remains securely fixed at large angles of heel, the Society may apply the* criteria given in [5.2.2] to [5.2.5], *which substitute those given in [2.1.2], [2.1.3], [2.1.4] and [2.1.5] and in [3].*

5.2.2 *The area under the righting lever curve (GZ curve) is to be not less than 0.08 m·rad up to θ = 40° or the angle of flooding if this angle is less than 40°.*

5.2.3 *The maximum value of the righting lever (GZ) is to be at least 0,25 m.*

5.2.4 *(1/7/2010)*

At all times during a voyage, the metacentric height GM_0 is to be not less than 0,1 m taking into account the absorption of water by the deck cargo and/or ice accretion on the exposed surfaces. (Details regarding ice accretion are given in [6]).

5.2.5 *When determining the ability of the ship to withstand the combined effect of beam wind and rolling according to [3], the 16° limiting angle of heel under action of steady wind is to be complied with, but the additional criterion of 80% of the angle of deck edge immersion may be ignored.*

5.3 Stability booklet

5.3.1 *The ship is to be supplied with comprehensive stability information which takes into account timber deck cargo. Such information is to enable the Master, rapidly and simply, to obtain accurate guidance as to the stability of the ship under varying conditions of service. Comprehensive rolling period tables or diagrams have proved to be very useful aids in verifying the actual stability conditions.*

5.3.2 *(1/7/2010)*

The Society may deem it necessary that the Master be given information setting out the changes in deck cargo from that shown in the loading conditions, when the permeability of the deck cargo is significantly different from 25% (see [5.4.1]).

5.3.3 *(1/7/2010)*

Conditions are to be shown indicating the maximum permissible amount of deck cargo having regard to the lightest stowage rate likely to be met in service.

5.4 Calculation of the stability curve

5.4.1 *In addition to the provisions given in App 2, [1.3], the Society may allow account to be taken of the buoyancy of the deck cargo assuming that such cargo has a permeability of 25% of the volume occupied by the cargo. Additional curves of stability may be required if the Society considers it necessary to investigate the influence of different permeabilities and/or assumed effective height of the deck cargo.*

5.5 Loading conditions to be considered

5.5.1 *The loading conditions which are to be considered for ships carrying timber deck cargoes are specified in App 2, [1.2.2]. For the purpose of these loading conditions, the ship is assumed to be loaded to the summer timber load line with water ballast tanks empty.*

5.6 Assumptions for calculating loading conditions

5.6.1 *The following assumptions are to be made for calculating the loading conditions referred to in App 2, [1.2.2]:*

- *the amount of cargo and ballast is to correspond to the worst service condition in which all the relevant stability criteria reported in [2.1.2], [2.1.3], [2.1.4] and [2.1.5], or the optional criteria given in [5.2], are met.*
- *In the arrival condition, it is to be assumed that the weight of the deck cargo has increased by 10% due to water absorption.*

5.6.2 *The stability of the ship at all times, including during the process of loading and unloading timber deck cargo, is to be positive and* in compliance with the stability criteria of [5.2]. *It is to be calculated having regard to:*

- *the increased weight of the timber deck cargo due to:*
  - *absorption of water in dried or seasoned timber, and*
  - *ice accretion, if applicable (as reported in [6])*
- *variations in consumable*
- *the free surface effect of liquid in tanks, and*
- *the weight of water trapped in broken spaces within the timber deck cargo and especially logs.*

5.6.3 *Excessive initial stability is to be avoided as it will result in rapid and violent motion in heavy seas which will impose large sliding and racking forces on the cargo causing high stresses on the lashings.* Unless otherwise stated in the stability booklet*, the metacentric height is* generally *not to exceed 3% of the breadth in order to prevent excessive acceleration in rolling provided that the relevant stability criteria given in [5.2] are satisfied.*

5.7 Stowage of timber deck cargoes

5.7.1 *The stowage of timber deck cargoes is to comply with the provisions of chapter 3 of the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 2011 (IMO Resolution A.1048(27)).*

6 Icing

6.1 General

6.1.1 *Ice formation is a complicated process which depends upon meteorological conditions, condition of loading and behaviour of the ship in stormy weather as well as on the size and location of superstructures and rigging. The most common cause of ice formation is the deposit of water droplets on the ship's structure. These droplets come from spray driven from wave crests and from ship-generated spray.*

6.1.2 *Ice formation may also occur in conditions of snowfall, sea fog including arctic sea smoke, a drastic fall in ambient temperature, as well as from the freezing of drops of rain on impact with the ship's structure.*

6.1.3 *Ice formation may sometimes be caused or accentuated by water shipped on board and retained on deck.*

6.1.4 *Intensive ice formation generally occurs on stem, bulwark and bulwark rail, front walls of superstructures and deckhouses, hawse holes, anchors, deck gear, forecastle deck and upper deck, freeing ports, aerials, stays, shrouds, masts and spars.*

6.1.5 *The most dangerous areas as far as ice formation is concerned are the sub-Arctic regions.*

6.1.6 *The most intensive ice formation takes place when wind and sea come from ahead. In beam and quartering winds, ice accumulates quicker on the windward side of the ship, thus leading to a constant list which can be extremely dangerous.*

6.1.7 *Listed below are meteorological conditions causing the most common type of ice formation due to spraying of a ship.*

a) *Slow accumulations of ice take place:*
   - *at ambient temperature from -1°C to -3°C and any wind force*
   - *at ambient temperature -4°C and lower and wind force from 0 to 9 m/s*
   - *under the conditions of precipitation, fog or sea mist followed by a drastic fall of the ambient temperature.*

b) *At ambient temperature of -4°C to -8°C and wind force 10-15 m/s, rapid accumulation of ice takes place. Under these conditions the intensity of ice accumulation can reach three times the amount normally accumulated in a).*

c) *Very fast accumulation of ice takes place:*
   - *at ambient temperature of -4°C and lower and wind forces of 16 m/s and over*
   - *at ambient temperature -9°C and lower and wind force 10 to 15 m/s.*

6.2 Icing accumulation consequences

6.2.1 *Ice formation adversely affects the seaworthiness of the ship as ice formation leads to:*

- *an increase in the weight of the ship due to accumulation of ice on the ship's surfaces which may cause the reduction of freeboard and buoyancy*
- *a rise of the ship's centre of gravity due to the high location of ice on the ship's structures with corresponding reduction in the level of stability*
- *an increase of windage area due to ice formation on the upper parts of the ship and hence an increase in the heeling moment due to the action of the wind*
- *the development of a constant list due to uneven distribution of ice across the breadth of the ship*
- *impairment of the manoeuvrability and reduction of the speed of the ship.*

6.3 Application

6.3.1 *For any ship operating in areas where ice accretion is likely to occur, adversely affecting a ship's stability, icing allowances are to be included in the analysis of conditions of loading.*

6.3.2 The Society is concerned to take icing into account and may apply national standards where environmental conditions warrant higher standards than those specified in the following regulations.

6.4 Ships carrying timber deck cargoes

6.4.1 *The Master is to establish or verify the stability of his ship for the worst service condition, having regard to the increased weight of deck cargo due to water absorption and/or ice accretion and to variations in consumable.*

6.4.2 *When timber deck cargoes are carried and it is anticipated that some formation of ice will take place, an allowance is to be made in the arrival condition for the additional weight.*

6.5 Calculation assumptions

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

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

6.5.2 *Ships intended for operation in areas where ice is known to occur are to be:*

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

6.6 Guidance relating to ice accretion

6.6.1 *The following icing areas are to be considered:*

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

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

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

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

e) *south of latitude 60°S.*

6.6.2 *For ships operating where ice accretion may be expected:*

- *within the areas defined in a), c), d) and e) of* [6.6.1] *known to having icing conditions significantly different from those described in [6.5], ice accretion requirements of one half to twice the required allowance may be applied;*
- *within the area defined in b), where ice accretion in excess of twice the allowance required by [6.5] may be expected, more severe requirements than those given in [6.5] may be applied.*

APPENDIX 1 INCLINING TEST AND LIGHTWEIGHT CHECK

1 Inclining test and lightweight check

1.1 General

1.1.1 General conditions of the ship *(1/7/2014)*

Prior to the test, the Society's Surveyor is to be satisfied of the following:

- the weather conditions are to be favourable
- the ship is to be moored in a quiet, sheltered area free from extraneous forces, such as to allow unrestricted heeling. The ship is to be positioned in order to minimise the effects of possible wind, stream and tide
- the ship is to be upright however, with inclining weights in the initial position, up to 0,5° of list is acceptable. The actual trim and deflection of keel, if practical, are to be considered in the hydrostatic data. In order to avoid excessive errors caused by significant changes in the water plane area during heeling, hydrostatic data for the actual trim and the maximum anticipated heeling angles are to be checked beforehand and the trim is to be taken not more than 1% of the length between perpendiculars. Otherwise, hydrostatic data and sounding tables are to be available for the actual trim
- cranes, derrick, lifeboats and liferafts capable of inducing oscillations are to be secured
- main and auxiliary boilers, pipes and any other system containing liquids are to be filled
- the bilge and the decks are to be thoroughly dried
- preferably, all tanks are to be empty and clean, or completely full. The number of tanks containing liquids is to be reduced to a minimum taking into account the above-mentioned trim. The shape of the tank is to be such that the free surface effect can be accurately determined and remain almost constant during the test. All cross connections are to be closed. In general, the total free surface correction is not to be greater than 150 mm; in particular cases, where the above limit is impracticable, the Society may accept higher values
- the weights necessary for the inclination are to be already on board, located in the correct place
- all work on board is to be suspended and crew or personnel not directly involved in the inclining test are to leave the ship
- the ship is to be as complete as possible at the time of the test. The number of weights to be removed, added or shifted is to be limited to a minimum. Temporary material, tool boxes, staging, sand, debris, etc., on board is to be reduced to an absolute minimum.

1.1.2 Inclining weights

The total weight used is preferably to be sufficient to provide a minimum inclination of one degree and a maximum of four degrees of heel to each side. The Society may, however, accept a smaller inclination angle for large ships provided that the requirement on pendulum deflection or U-tube difference in height specified in [1.1.4] is complied with. Test weights are to be compact and of such a configuration that the VCG (vertical centre of gravity) of the weights can be accurately determined. Each weight is to be marked with an identification number and its mass. Re-certification of the test weights is to be carried out prior to the incline. A crane of sufficient capacity and reach, or some other means, is to be available during the inclining test to shift weights on the deck in an expeditious and safe manner. Water ballast is generally not acceptable as inclining weight.

1.1.3 Water ballast as inclining weight *(1/7/2010)*

Where the use of solid weights to produce the inclining moment is demonstrated to be impracticable, the movement of ballast water may be permitted as an alternative method. This acceptance would be granted for a specific test only, and approval of the test procedure by the Society is required. As a minimal prerequisite for acceptability, the following conditions are to be required:

- *inclining tanks are to be wall-sided and free of large stringers or other internal members that create air pockets. Other tank geometries may be accepted at the discretion of the Society.*
- *tanks are to be directly opposite to maintain ship's trim*
- *specific gravity of ballast water is to be measured and recorded*
- *pipelines to inclining tanks are to be full. If the ship's piping layout is unsuitable for internal transfer, portable pumps and pipes/hoses may be used*
- *blanks must be inserted in transfer manifolds to prevent the possibility of liquids being "leaked" during transfer. Continuous valve control must be maintained during the test*
- *all inclining tanks must be manually sounded before and after each shift*
- *vertical, longitudinal and transverse centres are to be calculated for each movement*
- *accurate sounding/ullage tables are to be provided. The ship's initial heel angle is to be established prior to the incline in order to produce accurate values for volumes and transverse and vertical centres of gravity for the inclining tanks at every angle of heel. The draught marks amidships (port and starboard) are to be used when establishing the initial heel angle*
- *verification of the quantity shifted may be achieved by a flowmeter or similar device*
- *the time to conduct the inclining is to be evaluated. If time requirements for transfer of liquids are considered too long, water may be unacceptable because of the possibility of wind shifts over long periods of time.*

1.1.4 Pendulums *(1/7/2012)*

The use of three pendulums is recommended but a minimum of two are to be used to allow identification of bad readings at any one pendulum station. However, for ships of a length equal to or less than 30 m, only one pendulum can be accepted. *They are each to be located in an area protected from the wind. The pendulums are to be long enough to give a measured deflection, even due to partial shifting, to each side of upright, of at least* 10 cm*.*

To ensure recordings from individual instruments are kept separate, it is suggested that the pendulums should be physically located as far apart as practical.

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

1.1.5 Means of communications

Efficient two-way communications are to be provided between central control and the weight handlers and between central control and each pendulum station. One person at a central control station is to have complete control over all personnel involved in the test.

1.1.6 Documentation *(1/7/2010)*

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

- *lines plan*
- *hydrostatic curves or hydrostatic data*
- *general arrangement plan of decks, holds, inner bottoms, etc*
- *capacity plan showing capacities and vertical and longitudinal centres of gravity of cargo spaces, tanks, etc. When water ballast is used as inclining weights, the transverse and vertical centres of gravity for the applicable tanks, for each angle of inclination, must be available*
- *tank sounding tables*
- *draught mark locations, and*
- *docking drawing with keel profile and draught mark corrections (if available).*

1.1.7 Determination of the displacement

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

- draught mark readings are to be taken at aft, midship and forward, at starboard and port sides
- the mean draught (average of port and starboard reading) is to be calculated for each of the locations where draught readings are taken and plotted on the ship's lines drawing or outboard profile to ensure that all readings are consistent and together define the correct waterline. The resulting plot is to yield either a straight line or a waterline which is either hogged or sagged. If inconsistent readings are obtained, the freeboards/draughts are to be retaken
- the specific gravity of the sea water is to be determined. Samples are to be taken from a sufficient depth of the water to ensure a true representation of the sea water and not merely surface water, which could contain fresh water from run off of rain. A hydrometer is to be placed in a water sample and the specific gravity read and recorded. For large ships, it is recommended that samples of the sea water be taken forward, midship and aft, and the readings averaged. For small ships, one sample taken from midship is sufficient. The temperature of the water is to be taken and the measured specific gravity corrected for deviation from the standard, if necessary. A correction to water specific gravity is not necessary if the specific gravity is determined at the inclining experiment site. Correction is necessary if specific gravity is measured when the sample temperature differs from the temperature at the time of the inclining (e.g., if the check of specific gravity is performed at the office). Where the value of the average calculated specific gravity is different from that reported in the hydrostatic curves, adequate corrections are to be made to the displacement curve
- all double bottoms, as well as all tanks and compartments which can contain liquids, are to be checked, paying particular attention to air pockets which may accumulate due to the ship's trim and the position of air pipes, and also taking into account the provisions of [1.1.1]
- it is to be checked that the bilge is dry, and an evaluation of the liquids which cannot be pumped, remaining in the pipes, boilers, condenser, etc., is to be carried out
- the entire ship is to be surveyed in order to identify all items which need to be added, removed or relocated to bring the ship to the lightship condition. Each item is to be clearly identified by weight and location of the centre of gravity
- the possible solid permanent ballast is to be clearly identified and listed in the report.

1.1.8 The incline

The standard test generally employs eight distinct weight movements as shown in Tab 1.

Table 1 : Weight shift procedure *(1/7/2010)*

No. of Weights or Weight Groups				
Weight shifts	Four		Six	
	PS	SB	PS	SB
No. 0	2, 4	1, 3	2, 4, 6	1, 3, 5
No. 1	4	1, 2, 3	4, 6	1, 2, 3, 5
No. 2		1, 2, 3, 4		1, 2, 3, 4, 5, 6
No. 3	1	2, 3, 4	6	1, 2, 3, 4, 5
No. 4	1, 3	2, 4	2, 4, 6	1, 3, 5
No. 5	1, 2, 3,	4	1, 2, 3, 4, 6	5
No. 6	1, 2, 3, 4		1, 2, 3, 4, 5, 6	
No. 7	2, 3, 4	1	1, 2, 4, 6	3, 5
No. 8	2, 4	1, 3	2, 4, 6	1, 3, 5
PS and SB denotes port and starboard sides of ship respectively. The underlined numbers indicate the last weight groups shifted.				

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

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

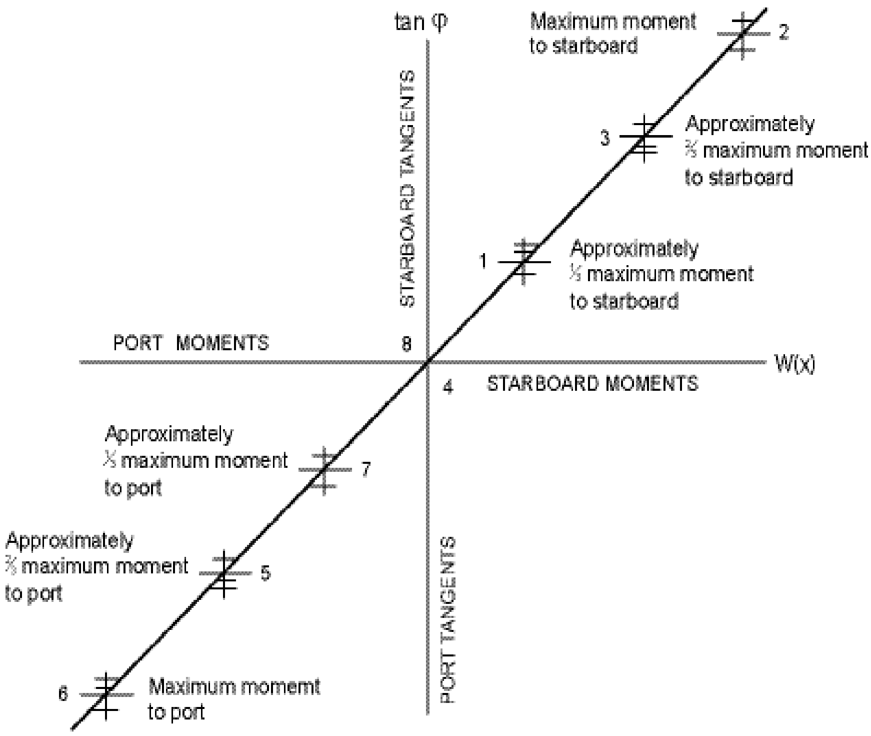
After each weight movement, the distance the weight was moved (centre to centre) is to be measured and the heeling moment calculated by multiplying the distance by the amount of weight moved. The tangent is calculated for each pendulum by dividing the deflection by the length of the pendulum. The resultant tangents are plotted on the graph as shown in Fig 1.

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

During the reading, no movements of personnel are allowed.

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

Figure 1 : Graph of resultant tangents *(1/7/2010)*



The plotting of all the readings for each of the pendulums during the inclining experiment aids in the discovery of bad readings. Since the ratio tangent/moment should be constant, the plotted line should be straight. Deviations from a straight line are an indication that there were other moments acting on the ship during the inclining. These other moments are to be identified, the cause corrected, and the weight movements repeated until a straight line is achieved. Fig 2 to Fig 5 illustrate examples of how to detect some of these other moments during the inclining, and a recommended solution for each case. For simplicity, only the average of the readings is shown on the inclining plots.

Figure 2 : Excessive free liquids (re-check all tanks and voids and pump out as necessary; re-do all weight movements and re-check freeboard and draught readings *(1/7/2010)*

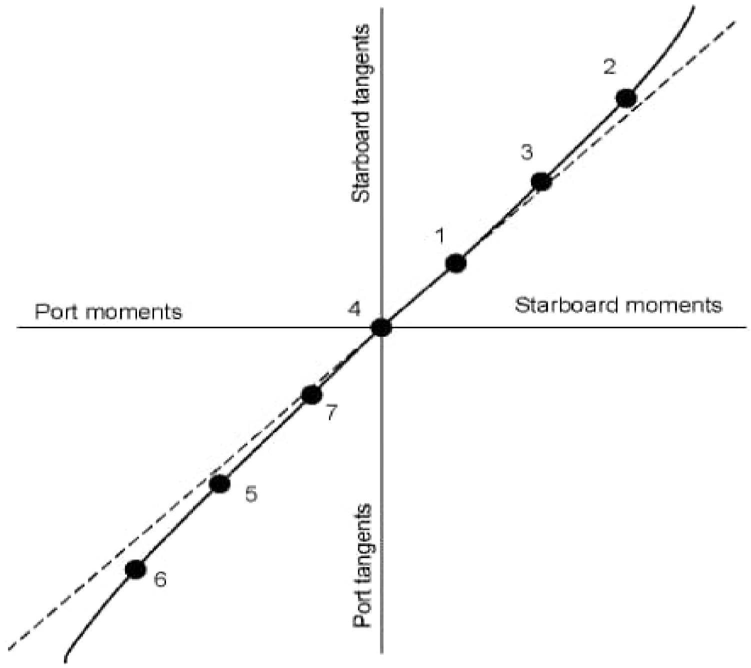


Figure 3 : Ship touching bottom or restrained by mooring lines (take water soundings and check lines: re-do weight movements 2 and 3) *(1/7/2010)*

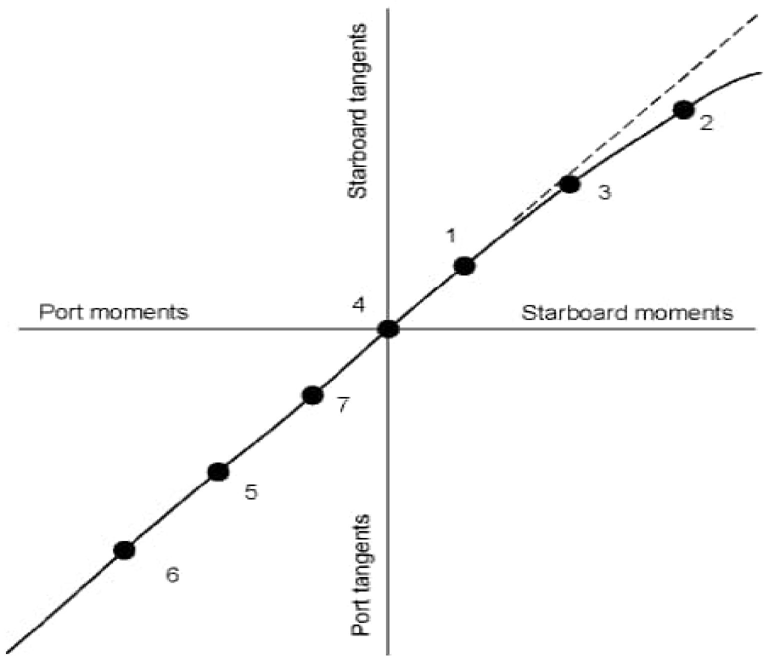


Figure 4 : Steady wind from port side came up after initial zero point taken (plot acceptable) *(1/7/2010)*

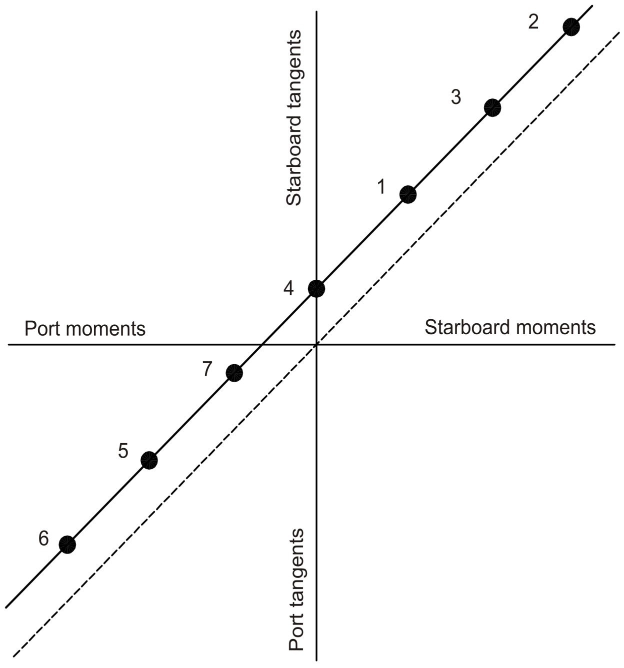
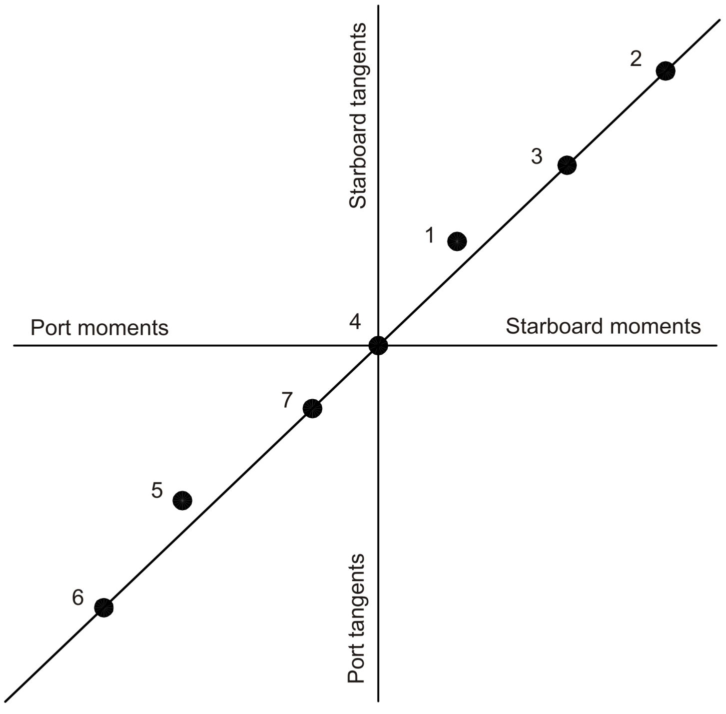


Figure 5 : Gusty wind from port side (re-do weight movements 1 and 5) *(1/7/2010)*



APPENDIX 2 TRIM AND STABILITY BOOKLET

1 Trim and stability booklet

1.1 Information to be included in the trim and stability booklet

1.1.1 General

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

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

1.1.2 List of information *(1/10/2005)*

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

- a general description of the ship, including:
  - the ship's name and the Society classification number
  - the ship type and service notation
  - the class notations
  - the yard, the hull number and the year of delivery
  - the Flag, the port of registry, the international call sign and the IMO number
  - the moulded dimensions
  - the draught corresponding to the assigned summer load line, the draught corresponding to the assigned summer timber load line and the draught corresponding to the tropical load line, if applicable
  - the displacement corresponding to the above-mentioned draughts
- clear instructions on the use of the booklet
- general arrangement and capacity plans indicating the assigned use of compartments and spaces (cargo, passenger, stores, accommodation, etc.)
- a sketch indicating the position of the draught marks referred to the ship's perpendiculars
- hydrostatic curves or tables corresponding to the design trim, and, if significant trim angles are foreseen during the normal operation of the ship, curves or tables corresponding to such range of trim are to be introduced. A clear reference relevant to the sea density, in t/m^3, is to be included as well as the draught measure (from keel or underkeel).
- cross curves (or tables) of stability calculated on a free trimming basis, for the ranges of displacement and trim anticipated in normal operating conditions, with indication of the volumes which have been considered in the computation of these curves
- tank sounding tables or curves showing capacities, centres of gravity, and free surface data for each tank
- lightship data from the inclining test, as indicated in Sec 1, [3.2], including lightship displacement, centre of gravity co-ordinates, place and date of the inclining test, as well as the Society approval details specified in the inclining test report. It is suggested that a copy of the approved test report be included.

  Where the above-mentioned information is derived from a sister ship, the reference to this sister ship is to be clearly indicated, and a copy of the approved inclining test report relevant to this sister ship is to be included.
- standard loading conditions as indicated in [1.2] and examples for developing other acceptable loading conditions using the information contained in the booklet
- intact stability results (total displacement and its centre of gravity co-ordinates, draughts at perpendiculars, GM, GM corrected for free surfaces effect, GZ values and curve, criteria as indicated in Sec 2, [2] and Sec 2, [3] as well as possible additional criteria specified in Part E when applicable, reporting a comparison between the actual and the required values) are to be available for each of the above-mentioned operating conditions. The method and assumptions to be followed in the stability curve calculation are specified in [1.3]
- information on loading restrictions (maximum allowable load on double bottom, maximum specific gravity allowed in liquid cargo tanks, maximum filling level or percentage in liquid cargo tanks) when applicable
- information about openings (location, tightness, means of closure), pipes or other progressive flooding sources
- any other necessary guidance for the safe operation of the ship
- a table of contents and index for each booklet.

1.2 Loading conditions

1.2.1 General

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

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

Additional loading conditions are required depending on the ship type and kind of cargo carried as specified in the following paragraphs, such loading cases being considered as a minimum requirement. Therefore, further loading cases may be included when deemed necessary or useful.

When a tropical freeboard is to be assigned to the ship, the corresponding loading conditions are also to be included.

1.2.2 Ships carrying cargo on deck *(1/7/2010)*

In addition to the loading conditions indicated in [1.2.1] to [1.2.13], in the case of cargo carried on deck the following cases are to be considered:

- *ship in the fully loaded departure condition having cargo homogeneously distributed in the holds and a with cargo specified in extension and mass on deck, with full stores and fuel*
- *ship in the fully loaded arrival condition having cargo homogeneously distributed in holds and a cargo specified in extension and weight on deck, with 10% stores and fuel.*

1.2.3 General cargo ships *(1/7/2010)*

In addition to the standard loading conditions reported in [1.2.1], at least the following loading cases are to be included in the trim and stability booklet:

- *ship in the fully loaded departure condition, with cargo homogeneously distributed throughout all cargo spaces and with full stores and fuel*
- *ship in the fully loaded arrival condition with cargo homogeneously distributed throughout all cargo spaces and with 10% stores and fuel remaining.*

For ships with service notation **general cargo ship** completed by the additional feature **nonhomload**, at least the following loading cases are also to be included in the trim and stability booklet:

- ship in the departure condition, with cargo in alternate holds, for at least three stowage factors, one of which is relevant to the summer load waterline and with full stores and consumables.

  Where the condition with cargo in alternate holds relevant to the summer load waterline leads to local loads on the double bottom greater than those allowed by the Society, it is to be replaced by the one in which each hold is filled in order to reach the maximum load allowed on the double bottom; in no loading case is such value to be exceeded
- same conditions as above, but with 10% stores and consumables.

1.2.4 Container ships

In addition to the standard loading conditions specified in [1.2.1], for ships with the service notation **container ship** at least the following loading cases are to be included in the trim and stability booklet:

- ship with the maximum number of containers on board having a homogeneous weight corresponding to the summer load waterline when loaded with full stores and consumables
- same loading condition as above, but with 10% stores and consumables
- ship with a number of containers having a weight corresponding to the maximum permissible weight for each container at the summer load waterline when loaded with full stores and consumables
- same loading condition as above, but with 10% stores and consumables
- lightship condition with full stores and consumables
- lightship condition with 10% stores and consumables.

The two latter conditions are to be included for information to the Master regarding the ship's stability before loading commences or unloading terminates.

The vertical location of the centre of gravity for each container is generally to be taken at one half of the container height. Different locations of the vertical centre of gravity may be accepted in specific cases, only if adequately documented.

1.2.5 Bulk carriers, ore carriers and combination carriers

Dry cargo is intended to mean grain, as well as any other type of solid bulk cargo.

The term grain covers wheat, maize (corn), oats, rye, barley, rice, pulses, seeds and processed forms thereof, whose behaviour is similar to that of grain in its natural state.

The term solid bulk cargo covers any material, other than liquid or gas, consisting of a combination of particles, granules or any larger pieces of material, generally uniform in composition, which is loaded directly into the cargo spaces of a ship without any intermediate form of containment.

In addition to the standard loading conditions defined in [1.2.1], for ships with the service notation **bulk carrier ESP**, **ore carrier ESP** and **combination carrier ESP** at least the following loading cases are to be included in the trim and stability booklet:

- ship in the fully loaded departure conditions at the summer load waterline, with cargo homogeneously distributed throughout all cargo holds and with full stores and consumables, for at least three specific gravities, one of which is relevant to the complete filling of all cargo holds
- same conditions as above, but with 10% stores and consumables
- ship in the departure condition, with cargo holds not entirely filled, for at least three stowage factors, one of which is relevant to the summer load waterline and with full stores and consumables
- same conditions as above, but with 10% stores and consumables.

For ships with one of the service notations **ore carrier ESP** and **combination carrier ESP** and for ships with the service notation **bulk carrier ESP** completed by the additional feature **nonhomload**, at least the following loading cases are also to be included in the trim and stability booklet:

- ship in the departure conditions, with cargo in alternate holds, for at least three stowage factors, one of which is relevant to the summer load waterline, and with full stores and consumables.

  Where the condition with cargo in alternate holds relevant to the summer load waterline leads to local loads on the double bottom greater than those allowed by the Society, it is to be replaced by the one in which each hold is filled in order to reach the maximum load allowed on the double bottom; in no loading case is such value to be exceeded.

- same conditions as above, but with 10% stores and consumables.

1.2.6 Oil tankers and FLS tankers *(1/10/2005)*

All the intended cargo loading conditions are to be included in the trim and stability booklet for examination within the scope of Pt E, Ch 7, Sec 3, [1].

In addition to the standard loading conditions specified in [1.2.1], for ships with the service notation **oil tanker ESP** or **FLS tanker** at least the following loading cases are to be included in the trim and stability booklet:

- ship in the fully loaded departure condition at the summer load waterline, with cargo homogeneously distributed throughout all cargo tanks and with full stores and consumables
- same condition as above, but with 10% stores and consumables
- ship in the departure condition loaded with a cargo having a density in order to fill all cargo tanks, with full stores and consumables, but immersed at a draught less than the summer load waterline
- same condition as above, but with 10% stores and consumables
- ship in the fully loaded departure condition at the summer load waterline, with cargo tanks not entirely filled and with full stores and consumables
- same condition as above, but with 10% stores and consumables
- two loading conditions corresponding to different cargo segregations in order to have slack tanks with full stores and consumables.

  When it is impossible to have segregations, these conditions are to be replaced by loading conditions with the same specific gravity and with slack cargo tanks.
- same loading condition as above, but with 10% stores and consumables
- For oil tankers having segregated ballast tanks as defined in Pt E, Ch 7, Sec 1, [1.3.14], the lightship condition with segregated ballast only is also to be included in the trim and stability booklet for examination.

1.2.7 Chemical tankers *(1/10/2005)*

All the intended cargo loading conditions are to be included in the trim and stability booklet for examination within the scope of IBC Code Ch 2, 2.9 and Ch 2, 2.8.1.6.

In addition to the standard loading conditions defined in [1.2.1], for ships with the service notation **chemical tanker ESP** at least the following loading cases are to be included in the trim and stability booklet:

- ship in the fully loaded departure condition, with cargo homogeneously distributed throughout all cargo tanks and with full stores and consumables
- same loading condition as above, but with 10% stores and consumables
- three loading conditions corresponding to different specific gravities with cargo homogeneously distributed throughout all cargo tanks and with full stores and consumables
- same loading conditions as above, but with 10% stores and consumables
- four loading conditions corresponding to different cargo segregations in order to have slack tanks with full stores and consumables. Cargo segregation is intended to mean loading conditions with liquids of different specific gravities.

  When it is impossible to have segregations, these conditions are to be replaced by loading conditions corresponding to different specific gravities with slack cargo tanks.
- same loading conditions as above, but with 10% stores and consumables.

  When it is impossible to have segregations, these conditions may be replaced by cases corresponding to different specific gravities with slack cargo tanks.

Possible limitations in the filling of cargo tanks due to structural matters (i.e sloshing) are to be taken into account and are to be clearly indicated in the booklet.

1.2.8 Liquefied gas carriers *(1/10/2005)*

All the intended cargo loading conditions are to be included in the trim and stability booklet for examination within the scope of IGC Code Ch 2, 2.9 and Ch 2, 2.8.1.6.

In addition to the standard loading conditions defined in [1.2.1], for ships with the service notation **liquefied gas carrier** at least the following loading cases are to be included in the trim and stability booklet:

- ship in the fully loaded departure condition, with cargo homogeneously distributed throughout all cargo spaces and with full stores and fuel
- ship in the fully loaded arrival condition with cargo homogeneously distributed throughout all cargo spaces and with 10% stores and fuel remaining.

1.2.9 Passenger ships *(1/7/2010)*

In addition to the standard loading conditions specified in [1.2.1], for ships with the service notation **passenger ship** at least the following loading cases are to be included in the trim and stability booklet:

- *ship in the fully loaded departure condition at the summer load line with cargo, with full stores and fuel and with the full number of passengers with their luggage;*
- *ship in the fully loaded arrival condition, with cargo, with the full number of passengers and their luggage but with only 10% stores and fuel remaining;*
- *ship without cargo, but with full stores and fuel and the full number of passengers and their luggage;*
- *ship in the same condition as above, but with only 10% stores and fuel remaining.*

1.2.10 Dredgers *(1/7/2006)*

For ships with one of the service notations **dredger**, **hopper dredger**, **hopper unit**, **split hopper dredger** and **split hopper unit**, the following loading conditions are to be considered:

a) Dredging unit in lightship condition

b) Dredging unit in ballast in the departure condition without dredged materials and with the dredging devices suitably lashed, with full stores and fuel

c) Dredging unit in ballast in the arrival condition, without dredged materials and with the dredging devices suitably lashed, with 10% stores and fuel remaining

d) Dredging unit in working condition with full stores and fuel, wells with homogeneous full loading of dredged spoil up to the overflow pipes or, where the latter are not fitted, up to the top of the hatchway and with draught corresponding to the summer freeboard

e) Dredging unit as per item d) but with only 10% of stores and fuel

f) Dredging unit in working condition with full stores and fuel, with wells with homogeneous partial loading of dredged spoil having mass density equal to 2,2 t/m^3 and with draught corresponding to the summer freeboard

g) Dredging unit as per item f) but with only 10% of stores and fuel.

1.2.11 Tugs and fire-fighting ships

In addition to the standard loading conditions defined in [1.2.1], for ships with one of the service notations **tug** and **fire fighting ship** at least the following loading cases are to be included in the trim and stability booklet:

- ship in the departure condition at the waterline corresponding to the maximum assigned immersion, with full stores, provisions and consumables
- same conditions as above, but with 10% stores and consumables.

1.2.12 Supply vessels

In addition to the standard loading conditions specified in [1.2.1], for ships with the service notation **supply vessel** at least the following loading cases are to be included in the trim and stability booklet:

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

1.2.13 Fishing vessels *(1/7/2010)*

In addition to the standard loading conditions defined in [1.2.1], for ships with the service notation **fishing vessel** at least the following loading cases are to be included in the trim and stability booklet:

- *departure conditions for the fishing grounds with full fuel stores, ice, fishing gear, etc.*
- *departure from the fishing grounds with full catch*
- *arrival at home port with 10% stores, fuel, etc. remaining and full catch*
- arrival at home port with 10% stores, fuel, etc. and a minimum catch, which is normally to be 20% of the full catch but may be up to 40% provided the Society is satisfied that operating patterns justify such a value.

1.3 Stability curve calculation

1.3.1 General *(1/7/2010)*

Hydrostatic and stability curves are normally prepared for the trim range of operating loading conditions taking into account the change in trim due to heel (free trim hydrostatic calculation).

The calculations are to take into account the volume to the upper surface of the deck sheathing.

1.3.2 Superstructures, deckhouses, etc. which may be taken into account *(1/7/2010)*

Enclosed superstructures complying with Ch 1, Sec 2, [3.10] may be taken into account.

Additional tiers of similarly enclosed superstructures may also be taken into account, except for ships of length less than 20 m, for which only the first tier of enclosed superstructures may be taken into account and, in the event of doors on both sides of a deckhouse, access from the top is not required.

As guidance, windows (pane and frame) that are considered without deadlights in additional tiers above the second tier if considered buoyant are to be designed with strength to sustain a safety margin of at least 30% with regard to the required strength of the surrounding structure.

Deckhouses on the freeboard deck may be taken into account, provided that they comply with the conditions for enclosed superstructures laid down in Ch 1, Sec 2, [3.12].

Where deckhouses comply with the above conditions, except that no additional exit is provided to a deck above, such deckhouses are not to be taken into account; however, any deck openings inside such deckhouses are to be considered as closed even where no means of closure are provided.

Deckhouses, the doors of which do not comply with the requirements of Ch 9, Sec 4, [1.5.4], are not to be taken into account; however, any deck openings inside the deckhouse are regarded as closed where their means of closure comply with the requirements of Ch 9, Sec 7, [7].

Deckhouses on decks above the freeboard deck are not to be taken into account, but openings within them may be regarded as closed.

Superstructures and deckhouses not regarded as enclosed may, however, be taken into account in stability calculations up to the angle at which their openings are flooded (at this angle, the static stability curve is to show one or more steps, and in subsequent computations the flooded space are to be considered non-existent).

Trunks may be taken into account. Hatchways may also be taken into account having regard to the effectiveness of their closures.

1.3.3 Angle of flooding

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

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

Part B

Hull and Stability

Chapter 4

STRUCTURE DESIGN PRINCIPLES

SECTION 1 MATERIALS

1 General

1.1 Characteristics of materials

1.1.1 The characteristics of the materials to be used in the construction of ships are to comply with the applicable requirements of Part D.

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

1.2 Testing of materials

1.2.1 Materials are to be tested in compliance with the applicable requirements of Part D.

1.3 Manufacturing processes

1.3.1 The requirements of this Section presume that welding and other cold or hot manufacturing processes are carried out in compliance with current sound working practice and the applicable requirements of Part D. In particular:

- parent material and welding processes are to be approved within the limits stated for the specified type of material for which they are intended
- specific preheating may be required before welding
- welding or other cold or hot manufacturing processes may need to be followed by an adequate heat treatment.

2 Steels for hull structure

2.1 Application

2.1.1 Tab 1 gives the mechanical characteristics of steels currently used in the construction of ships.

2.1.2 Higher strength steels other than those indicated in Tab 1 are considered by the Society on a case by case basis.

2.1.3 When steels with a minimum guaranteed yield stress R_{eH} other than 235 N/mm² are used on a ship, hull scantlings are to be determined by taking into account the material factor k defined in [2.3].

2.1.4 Characteristics of steels with specified through thickness properties are given in Pt D, Ch 2, Sec 1, [9].

2.2 Information to be kept on board

2.2.1 A plan is to be kept on board indicating the steel types and grades adopted for the hull structures. Where steels other than those indicated in Tab 1 are used, their mechanical and chemical properties, as well as any workmanship requirements or recommendations, are to be available on board together with the above plan.

2.2.2 It is also recommended that a plan is kept on board indicating the hull structures built in normal strength steel of grades D or E.

Table 1 : Mechanical properties of hull steels *(1/1/2022)*

Steel grades	Minimum yield stress R_{eH}, in N/mm²	Ultimate minimum tensile strength R_m, in N/mm²
A-B-D-E t ≤ 100mm	235	400 - 520
AH32-DH32-EH32 t ≤ 100mm FH32 t ≤ 50mm	315	440 - 570
AH36-DH36-EH36 t ≤ 100mm FH36 t ≤ 50mm	355	490 - 630
AH40-DH40-EH40 FH40 t ≤ 50mm	390	510 - 660
EH47	460	570 - 720
Note 1: Reference in Part D: Pt D, Ch 2, Sec 1, [2]		

2.3 Material factor k

2.3.1 General *(1/7/2017)*

Unless otherwise specified, the material factor k has the values defined in Tab 2, as a function of the minimum guaranteed yield stress R_{eH}.

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

Steels with a yield stress lower than 235 N/mm² or greater than 460 N/mm² are considered by the Society on a case by case basis.

Table 2 : Material factor k *(1/7/2017)*

R_{eH} , in N/mm²	k
235	1
315	0,78
355	0,72
390	0,68 **(1)**
460	0,62
(1) 0,66 provided that a fatigue assessment of the structure is performed to verify compliance with Pt B, Ch 7, Sec 4	

2.4 Grades of steel

2.4.1 *(1/7/2021)*

Materials in the various strength members are not to be of lower grade than those corresponding to the material classes and grades specified in Tab 3 to Tab 7. General requirements are given in Tab 3, while additional minimum requirements for ships with length exceeding 150 m and 250 m are given in Tab 4 and Tab 5.

2.4.2 *(1/7/2021)*

The material grade requirements for hull members of each class depending on the thickness are defined in Tab 7.

Table 3 : Material Classes and Grades for ships in general *(1/7/2014)*

Structural member category	Material class/grade
SECONDARY: • Longitudinal bulkhead strakes, other than that belonging to the Primary category • Deck plating exposed to weather, other than that belonging to the Primary or Special category • Side plating	• Class I within 0,4L amidships • Grade A/AH outside 0,4L amidships
PRIMARY: • Bottom plating, including keel plate • Strength deck plating, excluding that belonging to the Special category • Continuous longitudinal plating of strength members above strength deck, excluding hatch coamings • Uppermost strake in longitudinal bulkhead • Vertical strake (hatch side girder) and uppermost sloped strake in top wing tank	• Class II within 0,4L amidships • Grade A/AH outside 0,4L amidships
SPECIAL: • Sheerstrake at strength deck **(1)** • Stringer plate in strength deck **(1)** • Deck strake at longitudinal bulkhead, excluding deck plating in way of inner-skin bulkhead of double hull ships **(1)**	• Class III within 0,4L amidships • Class II outside 0,4L amidships • Class I outside 0,6L amidships
• Strength deck plating at outboard corners of cargo hatch openings in container carriers and other ships with similar hatch opening configurations	• Class III within 0,4L amidships • Class II outside 0,4L amidships • Class I outside 0,6L amidships • Min. Class III within cargo region
• Strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers, combination carriers and other ships with similar hatch opening configurations	• Class III within 0,6L amidships • Class II within rest of cargo region
• Bilge strake in ships with double bottom over the full breadth and length less than 150 m **(1)**	• Class II within 0,6L amidships • Class I outside 0,6L amidships
• Bilge strake in other ships **(1)**	• Class III within 0,4L amidships • Class II outside 0,4L amidships • Class I outside 0,6L amidships
• Longitudinal hatch coamings of length greater than 0,15L including coaming top plate and flange • End brackets and deck house transition of longitudinal cargo hatch coamings	• Class III within 0,4L amidships • Class II outside 0,4L amidships • Class I outside 0,6L amidships • Not to be less than Grade D/DH
(1) Single strakes required to be of Class III within 0,4L amidships are to have breadths not less than 800+5L (mm), but need not be greater than 1800 (mm), unless limited by the geometry of the ship's design.	

Table 4 : Minimum Material Grades for ships with length exceeding 150 m and single strength deck *(1/7/2014)*

Structural member category	Material grade
• Longitudinal plating of strength deck where contributing to the longitudinal strength • Continuous longitudinal plating of strength members above strength deck	Grade B/AH within 0,4L amidships
Single side strakes for ships without inner continuous longitudinal bulkhead(s) between bottom and the strength deck	Grade B/AH within cargo region

Table 5 : Minimum Material Grades for ships with length exceeding 250 m *(1/1/2022)*

Structural member category	Material grade
Sheer strake at strength deck **(1)**	Grade E/EH within 0,4L amidships
Stringer plate in strength deck **(1)**	Grade E/EH within 0,4L amidships
Bilge strake **(1)**	Grade D/DH within 0,4L amidships
(1) Single strakes required to be of Grade D/DH or Grade E/EH as shown in this table and within 0,4L amidships are to have breadths not less than 800+5L (mm), but need not be greater than 1800 (mm), unless limited by the geometry of the ship's design.	

Table 6 : Minimum Material Grades for single-side skin bulk carriers subjected to SOLAS regulation XII/6.4 *(1/7/2021)*

Structural member category	Material grade
Lower bracket of ordinary side frame **(1)**, **(2)**	Grade D/DH
Side shell strakes included totally or partially between the two points located to 0,125 ℓ above and below the intersection of side shell and bilge hopper sloping plate or inner bottom plate **(2)**	Grade D/DH
(1) The term "lower bracket" means webs of lower brackets and webs of the lower part of side frames up to the point of 0,125 ℓ above the intersection of side shell and bilge hopper sloping plate or inner bottom plate. **(2)** The span of the side frame, ℓ, is defined as the distance between the supporting structures.	

Table 7 : Material grade requirements for classes I, II and III

Class	I		II		III	
Gross thickness, in mm	NSS	HSS	NSS	HSS	NSS	HSS
t ≤ 15	A	AH	A	AH	A	AH
15 < t ≤ 20	A	AH	A	AH	B	AH
20 < t ≤ 25	A	AH	B	AH	D	DH
25 < t ≤ 30	A	AH	D	DH	D	DH
30 < t ≤ 35	B	AH	D	DH	E	EH
35 < t ≤ 40	B	AH	D	DH	E	EH
40 < t ≤ 50	D	DH	E	EH	E	EH
Note 1:“NSS” and “HSS” mean, respectively: “Normal Strength Steel” and “Higher Strength Steel”.						

2.4.3 *(1/7/2021)*

For strength members not mentioned in Tab 3 to Tab 5, grade A/AH may generally be used.

2.4.4 *(1/7/2014)*

The steel grade is to correspond to the as-built plate thickness and material class.

2.4.5 Steel grades of plates or sections of gross thickness greater than the limiting thicknesses in Tab 1 are considered by the Society on a case by case basis.

2.4.6 In specific cases, such as [2.4.7], with regard to stress distribution along the hull girder, the classes required within 0,4L amidships may be extended beyond that zone, on a case by case basis.

2.4.7 The material classes required for the strength deck plating, the sheerstrake and the upper strake of longitudinal bulkheads within 0,4L amidships are to be maintained for an adequate length across the poop front and at the ends of the bridge, where fitted.

2.4.8 Rolled products used for welded attachments on hull plating, such as gutter bars and bilge keels, are to be of the same grade as that used for the hull plating in way.

Where it is necessary to weld attachments to the sheerstrake or stringer plate, attention is to be given to the appropriate choice of material and design, the workmanship and welding and the absence of prejudicial undercuts and notches, with particular regard to any free edges of the material.

2.4.9 In the case of grade D plates with a nominal thickness equal to or greater than 36 mm, or in the case of grade DH plates with a nominal thickness equal to or greater than 31 mm, the Society may, on a case by case basis, require the impact test to be carried out on each original "rolled unit", where the above plates:

- either are to be placed in positions where high local stresses may occur, for instance at breaks of poop and bridge, or in way of large openings on the strength deck and on the bottom, including relevant doublings, or
- are to be subjected to considerable cold working.

2.4.10 In the case of full penetration welded joints located in positions where high local stresses may occur perpendicular to the continuous plating, the Society may, on a case by case basis, require the use of rolled products having adequate ductility properties in the through thickness direction, such as to prevent the risk of lamellar tearing (Z type steel, see Part D).

2.4.11 In highly stressed areas, the Society may require that plates of gross thickness greater than 20 mm are of grade D/DH or E/EH.

2.4.12 For certain uses, grade B steel with controlled toughness at 0°C may be required for plates of gross thickness less than 25 mm.

2.4.13 *(1/7/2008)*

Plating materials for sternframes, rudders, rudder horns and shaft brackets are, in general, not to be of lower grades than corresponding to Class II. For rudder and rudder body plates subjected to stress concentrations (e.g. in way of lower support of semi-spade rudders or at upper part of spade rudders), Class III is to be applied.

2.5 Grades of steel for ships exposed to low air temperatures

2.5.1 *(1/7/2019)*

For ships intended to operate in areas with low air temperatures (below -10°C), e.g. regular service during winter seasons to Arctic or Antarctic waters, the materials in exposed structures are to be selected based on the design temperature t_D, to be taken as defined in [2.5.2].

2.5.2 *(1/1/2017)*

The design temperature t_D is to be taken as the lowest mean daily average air temperature in the area of operation, where:

Mean : Statistical mean over observation period

Average : Average during one day and night

Lowest : Lowest during one year

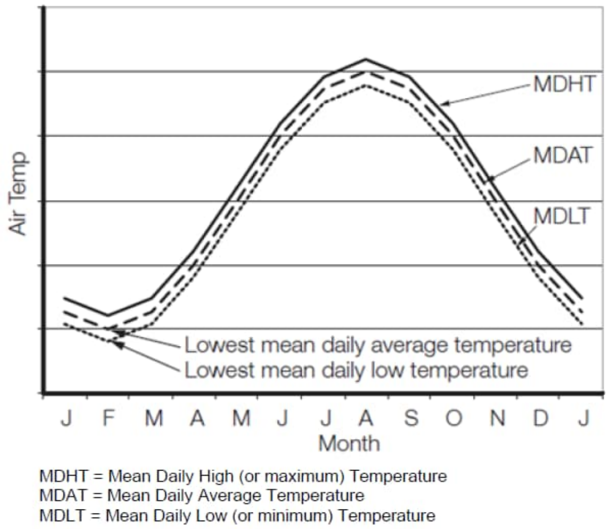
Fig 1 illustrates the temperature definition.

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

For the purpose of issuing a Polar Ship Certificate in accordance with the Polar Code, the design temperature t_D shall be no more than 13°C higher than the Polar Service Temperature (PST) of the ship.

In the Polar Regions, the statistical mean over observation period is to be determined for a period of at least 10 years.

Figure 1 : Commonly used definitions of temperatures *(1/7/2021)*



2.5.3 *(1/7/2021)*

For the purpose of the selection of steel grades to be used for the structural members above the lowest ballast waterline and exposed to air (including the structural members covered by the Note 6 of Tab 8 and the cargo tank boundary plating exposed to cold cargo covered by the Note 7 of Tab 8, for which [2.5.6] is applicable), these are divided into categories (SECONDARY, PRIMARY and SPECIAL), as indicated in Tab 8.

Tab 8 also specifies the classes (I, II and III) of the materials to be used for the various categories of structural members.

For non-exposed structures (except as indicated in Note 6 of Tab 8 and structures below the lowest ballast waterline, [2.4] applies.

2.5.4 *(1/7/2021)*

Materials may not be of a lower grade than that indicated in Tab 9 to Tab 11 depending on the material class, structural member gross thickness and design temperature t_D.

For design temperatures t_D < -55°C, materials will be specially considered by the Society on a case by case basis.

2.5.5 Single strakes required to be of class III or of grade E/EH of FH are to have breadths not less than (800+5L) mm, but not necessarily greater than 1800 mm.

2.5.6 *(1/7/2021)*

For ships other than liquefied gas carriers, intended to be loaded with liquid cargo having a temperature below -10°C, e.g. loading from cold onshore storage tanks during winter conditions, the material grade of cargo tank boundary plating is defined in Tab 9 based on the following:

- t_c design minimum cargo temperature in °C
- steel grade corresponding to Class I.

The design minimum cargo temperature, t_c is to be specified in the loading manual.

2.6 Grades of steel within refrigerated spaces

2.6.1 *(1/7/2021)*

For structural members within or adjacent to refrigerated spaces, when the design temperatures is below 0°C, the materials are to be of grade not lower than those indicated in Tab 12, depending on the design temperature, the structural member gross thickness and its category (as defined in Tab 3).

2.6.2 Unless a temperature gradient calculation is carried out to assess the design temperature and the steel grade in the structural members of the refrigerated spaces, the temperatures to be assumed are specified below:

- temperature of the space on the uninsulated side, for plating insulated on one side only, either with uninsulated stiffening members (i.e. fitted on the uninsulated side of plating) or with insulated stiffening members (i.e. fitted on the insulated side of plating)
- mean value of temperatures in the adjacent spaces, for plating insulated on both sides, with insulated stiffening members, when the temperature difference between the adjacent spaces is generally not greater than 10 °C (when the temperature difference between the adjacent spaces is greater than 10°C, the temperature value is established by the Society on a case by case basis)
- in the case of non-refrigerated spaces adjacent to refrigerated spaces, the temperature in the non-refrigerated spaces is to be conventionally taken equal to 0°C.

2.6.3 Situations other than those mentioned in [2.6.1] and [2.6.2] or special arrangements will be considered by the Society on a case by case basis.

2.6.4 *(1/7/2021)*

Irrespective of the provisions of [2.6.1], [2.6.2] and Tab 12, steel having grades lower than those required in [2.4], Tab 3 to Tab 7, in relation to the class and gross thickness of the structural member considered, may not be used.

Table 8 : Application of material classes and grades for structures exposed to low air temperatures *(1/7/2019)*

Structural member category	Material class	
	Within 0,4L amidships	Outside 0,4L amidships
SECONDARY: Deck plating exposed to weather (in general) Side plating above T_B **(1)** Transverse bulkheads above T_B **(1)** **(6)** Cargo tank boundary plating exposed to cold cargo **(7)**	I	I
PRIMARY: Strength deck plating **(2)** Continuous longitudinal members above strength deck (excluding longitudinal hatch coamings of ships equal to or greater than 90 m in length) Longitudinal bulkhead above T_B **(1)** **(6)** Topside tank bulkhead above T_B **(1)** **(6)**	II	I
SPECIAL: Sheer strake at strength deck **(3)** Stringer plate in strength deck **(3)** Deck strake at longitudinal bulkhead **(4)** Continuous longitudinal hatch coamings of ships equal to or greater than 90 m in length **(5)**	III	II

(1) T_B is the draught in light ballast condition, defined in Ch 5, Sec 1, [2.4.3].
(2) Plating at corners of large hatch openings to be considered on a case by case basis. Class III or grade E/EH to be applied in positions where high local stresses may occur.
(3) To be not less than grade E/EH within 0,4 L amidships in ships with length exceeding 250 m.
(4) In ships with breadth exceeding 70 metres at least three deck strakes to be class III.
(5) To be not less than grade D/DH.
(6) Applicable to plating attached to hull envelope plating exposed to low air temperature. At least one strake is to be considered in the same way as exposed plating and the strake width is to be at least 600 mm.
(7) For cargo tank boundary plating exposed to cold cargo for ships other than liquefied gas carriers, see [2.5.6].
Note 1: Plating materials for sternframes, rudder horns, rudders and shaft brackets are to be of grades not lower than those corresponding to the material classes in [2.4].

Table 9 : Material grade requirements for class I at low temperatures *(1/7/2021)*

Gross thickness, in mm	-11°C / -15°C		-16°C / -25°C		-26°C / -35°C		-36°C / -45°C		-46°C / -55°C	
	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS
t ≤ 10	A	AH	A	AH	B	AH	D	DH	D	DH
10 < t ≤ 15	A	AH	B	AH	D	DH	D	DH	D	DH
15 < t ≤ 20	A	AH	B	AH	D	DH	D	DH	E	EH
20 < t ≤ 25	B	AH	D	DH	D	DH	D	DH	E	EH
25 < t ≤ 30	B	AH	D	DH	D	DH	E	EH	E	EH
30 < t ≤ 35	D	DH	D	DH	D	DH	E	EH	E	EH
35 < t ≤ 45	D	DH	D	DH	E	EH	E	EH	ϕ	FH
45 < t ≤ 50	D	DH	E	EH	E	EH	ϕ	FH	ϕ	FH

Note 1:"NSS" and "HSS" mean, respectively, "Normal Strength Steel" and "Higher Strength Steel".
Note 2:"ϕ" = not applicable.

Table 10 : Material grade requirements for class II at low temperatures *(1/7/2021)*

Gross thickness, in mm	-11°C / -15°C		-16°C / -25°C		-26°C / -35°C		-36°C / -45°C		-46°C / -55°C	
	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS
t ≤ 10	A	AH	B	AH	D	DH	D	DH	E	EH
10 < t ≤ 20	B	AH	D	DH	D	DH	E	EH	E	EH
20 < t ≤ 30	D	DH	D	DH	E	EH	E	EH	ϕ	FH
30 < t ≤ 40	D	DH	E	EH	E	EH	ϕ	FH	ϕ	FH
40 < t ≤ 45	E	EH	E	EH	ϕ	FH	ϕ	FH	ϕ	ϕ
45 < t ≤ 50	E	EH	E	EH	ϕ	FH	ϕ	FH	ϕ	ϕ

Note 1:"NSS" and "HSS" mean, respectively, "Normal Strength Steel" and "Higher Strength Steel".
Note 2:"ϕ" = not applicable.

Table 11 : Material grade requirements for class III at low temperatures *(1/7/2019)*

Gross thickness, in mm	-11°C / -15°C		-16°C / -25°C		-26°C / -35°C		-36°C / -45°C		-46°C / -55°C	
	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS
t ≤ 10	B	AH	D	DH	D	DH	E	EH	E	EH
10 < t ≤ 20	D	DH	D	DH	E	EH	E	EH	ϕ	FH
20 < t ≤ 25	D	DH	E	EH	E	EH	E	FH	ϕ	FH
25 < t ≤ 30	D	DH	E	EH	E	EH	ϕ	FH	ϕ	FH
30 < t ≤ 35	E	EH	E	EH	ϕ	FH	ϕ	FH	ϕ	ϕ
35 < t ≤ 40	E	EH	E	EH	ϕ	FH	ϕ	FH	ϕ	ϕ
40 < t ≤ 50	E	EH	ϕ	FH	ϕ	FH	ϕ	ϕ	ϕ	ϕ

Note 1:"NSS" and "HSS" mean, respectively, "Normal Strength Steel" and "Higher Strength Steel".
Note 2:"ϕ" = not applicable.

Table 12 : Material grade requirements for members within or adjacent to refrigerated spaces

Design temperature, in °C	Gross thickness, in mm	Structural member category	
		Secondary	Primary or Special
$-10 \le t_D < 0$	$t \le 20$	B / AH	B / AH
	$20 < t \le 25$	B / AH	D / DH
	$t > 25$	D / DH	E / EH
$-25 \le t_D < -10$	$t \le 15$	B / AH	D / DH
	$15 < t \le 25$	D / DH	E / EH
	$t > 25$	E / EH	E / EH
$-40 \le t_D < -25$	$t \le 25$	D / DH	E / EH
	$t > 25$	E / EH	E / EH

3 Steels for forging and casting

3.1 General

3.1.1 Mechanical and chemical properties of steels for forging and casting to be used for structural members are to comply with the applicable requirements of Part D.

3.1.2 Steels of structural members intended to be welded are to have mechanical and chemical properties deemed appropriate for this purpose by the Society on a case by case basis.

3.1.3 The steels used are to be tested in accordance with the applicable requirements of Part D.

3.2 Steels for forging

3.2.1 For the purpose of testing, which is to be carried out in accordance with the applicable requirements of Part D, the above steels for forging are assigned to class 1 (see Pt D, Ch 2, Sec 3, [1.2]).

3.2.2 Rolled bars may be accepted in lieu of forged products, after consideration by the Society on a case by case basis.

In such case, compliance with the requirements of Pt D, Ch 2, Sec 1, relevant to the quality and testing of rolled parts accepted in lieu of forged parts, may be required.

3.3 Steels for casting

3.3.1 Cast parts intended for stems, sternframes, rudders, parts of steering gear and deck machinery in general may be made of C and C-Mn weldable steels of quality 1, having tensile strength R_m = 400 N/mm^2 or 440 N/mm^2, in accordance with the applicable requirements of Pt D, Ch 2, Sec 4.

Items which may be subjected to high stresses may be required to be of quality 2 steels of the above types.

3.3.2 For the purpose of testing, which is to be carried out in accordance with Pt D, Ch 2, Sec 4, [1.11], the above steels for casting are assigned to class 1 irrespective of their quality.

3.3.3 The welding of cast parts to main plating contributing to hull strength members is considered by the Society on a case by case basis.

The Society may require additional properties and tests for such casting, in particular impact properties which are appropriate to those of the steel plating on which the cast parts are to be welded and non-destructive examinations.

3.3.4 Heavily stressed cast parts of steering gear, particularly those intended to form a welded assembly and tillers or rotors mounted without key, are to be subjected to non-destructive examination to check their internal structure.

4 Aluminium alloy structures

4.1 General

4.1.1 The characteristics of aluminium alloys are to comply with the requirements of Pt D, Ch 3, Sec 2.

Series 5000 aluminium-magnesium alloys or series 6000 aluminium-magnesium-silicon alloys are generally to be used (see Pt D, Ch 3, Sec 2, [2]).

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

4.2 Extruded plating

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

4.2.2 In general, the application is limited to decks, bulkheads, superstructures and deckhouses. Other uses may be permitted by the Society on a case by case basis.

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

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

4.3 Influence of welding on mechanical characteristics

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

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

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

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

4.3.4 Aluminium alloys of series 5000 other than condition 0 or H111 are subject to a drop in mechanical strength in the welded areas.

The mechanical characteristics to consider are normally those of condition 0 or H111.

Higher mechanical characteristics may be taken into account, provided they are duly justified.

4.3.5 Aluminium alloys of series 6000 are subject to a drop in mechanical strength in the vicinity of the welded areas.

The mechanical characteristics to be considered are normally indicated by the supplier.

4.4 Material factor k

4.4.1 *(1/7/2021)*

The material factor k for aluminium alloys is to be obtained from the following formula:

$$k = \frac{235}{\eta R_{p0,2}}$$

where:

η : Joint coefficient for the welded assembly, corresponding to the aluminium alloy considered, given in Tab 13

$R_{p0,2}$: Minimum guaranteed yield stress, in N/mm², of the parent material in delivery condition.

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

5 Other materials and products

5.1 General

5.1.1 Other 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 generally to comply with the applicable requirements of Part D.

5.1.2 The use of plastics or other special materials not covered by these Rules is to be considered by the Society on a case by case basis. In such cases, the Society states the requirements for the acceptance of the materials concerned.

5.1.3 Materials used in welding processes are to comply with the applicable requirements of Part D.

5.2 Iron cast parts

5.2.1 As a rule, the use of grey iron, malleable iron or spheroidal graphite iron cast parts with combined ferritic/perlitic structure is allowed only to manufacture low stressed elements of secondary importance.

5.2.2 Ordinary iron cast parts may not be used for windows or sidescuttles; the use of high grade iron cast parts of a suitable type will be considered by the Society on a case by case basis.

Table 13 : Joint coefficient for aluminium alloys *(1/7/2021)*

Aluminium alloy	η
Alloys without work-hardening treatment (series 5000 in annealed condition 0 or annealed flattened condition H111)	1
Alloys hardened by work hardening (series 5000 other than condition 0 or H111)	$R'_{p0,2}/R_{p0,2}$
Alloys hardened by heat treatment (series 6000) **(1)**	$R'_{p0,2}/R_{p0,2}$

(1) When no information is available, coefficient η is to be taken equal to the metallurgical efficiency coefficient β defined in Tab 14.

Note 1:

$R'_{p0,2}$: Minimum guaranteed yield stress, in N/mm², of material in welded condition (see [4.3]).

Table 14 : Aluminium alloys Metallurgical efficiency coefficient β

Aluminium alloy	Temper condition	Gross thickness, in mm	β
6005 A (Open sections)	T5 or T6	$t \le 6$	0,45
		$t > 6$	0,40
6005 A (Closed sections)	T5 or T6	All	0,50
6061 (Sections)	T6	All	0,53
6082 (Sections)	T6	All	0,45

SECTION 2 NET SCANTLING APPROACH

Symbols

t_N : Net thickness, in mm, of plating, including that which constitutes primary supporting members

w_N : Net section modulus, in cm^3, of ordinary stiffeners

w_G : Gross section modulus, in cm^3, of ordinary stiffeners.

1 Application criteria

1.1 General

1.1.1 The scantlings obtained by applying the criteria specified in Part B are net scantlings, i.e. those which provide the strength characteristics required to sustain the loads, excluding any addition for corrosion. Exceptions are:

- the scantlings obtained from the yielding checks of the hull girder in Ch 6, Sec 2
- the scantlings of doors in Ch 9, Sec 5 and Ch 9, Sec 6
- the scantlings of rudder structures and hull appendages in Chapter 10,

which are gross scantlings, i.e. they include additions for corrosion.

1.1.2 The required strength characteristics are:

- thickness, for plating including that which constitutes primary supporting members
- section modulus, shear area, moments of inertia and local thickness, for ordinary stiffeners and, as the case may be, primary supporting members
- section modulus, moments of inertia and single moment for the hull girder.

1.1.3 The ship is to be built at least with the gross scantlings obtained by adding the corrosion additions, specified in Tab 2, to the net scantlings.

2 Net strength characteristic calculation

2.1 Designer's proposal based on gross scantlings

2.1.1 General criteria

If the Designer provides the gross scantlings of each structural element, the structural checks are to be carried out on the basis of the net strength characteristics, derived as specified in [2.1.2] to [2.1.6].

2.1.2 Plating

The net thickness is to be obtained by deducting t_c from the gross thickness.

2.1.3 Ordinary stiffeners

The net transverse section is to be obtained by deducting t_C from the gross thickness of the elements which constitute the stiffener profile. For bulb profiles, an equivalent angle profile, as specified in Sec 3, [3.1.2], may be considered.

The net strength characteristics are to be calculated for the net transverse section. As an alternative, the net section modulus may be obtained from the following formula:

$$w_N = w_G(1 - \alpha t_C) - \beta t_C$$

where α and β are the coefficients defined in Tab 1.

Table 1 : Coefficients α and β

Type of ordinary stiffeners	α	β
Flat bars	0,035	2,8
Flanged profiles	0,060	14,0
Bulb profiles: $w_G \leq 200$ cm^3 $w_G > 200$ cm^3	 0,070 0,035	 0,4 7,4

2.1.4 Primary supporting members analysed through an isolated beam structural model

The net transverse section is to be obtained by deducting t_C from the gross thickness of the elements which constitute the primary supporting members.

The net strength characteristics are to be calculated for the net transverse section.

2.1.5 Primary supporting members analysed through a three dimensional model or a complete ship model

The net thickness of the structure elements represented in the model is to be obtained by deducting $0,5t_c$ from the gross thickness.

2.1.6 Hull girder

For the hull girder, the net hull transverse sections are to be considered as being constituted by plating and stiffeners having net scantlings calculated on the basis of the corrosion additions t_C , according to [2.1.2] to [2.1.4].

It is to be checked whether:

$$Z_{NA} \geq 0,9 Z_{GD}$$

where:

Z_{NA} : Net midship section modulus, in m^3, calculated on the basis of the net scantlings obtained considering the corrosion additions t_C according to [2.1.2] to [2.1.4]

Z_{GD} : Gross midship section modulus, in m^3, calculated on the basis of the gross scantlings proposed by the Designer.

Where the above condition is not satisfied, the hull girder normal and shear stresses, to be used for the checks of plating, ordinary stiffeners and primary supporting members analysed through an isolated beam structural model, are to be obtained by dividing by 0,9 those obtained by considering the hull girder transverse sections with their gross scantlings.

2.2 Designer's proposal based on net scantlings

2.2.1 Net strength characteristics and corrosion additions

If the Designer provides the net scantlings of each structural element, the structural checks are to be carried out on the basis of the proposed net strength characteristics.

The Designer is also to provide the corrosion additions or the gross scantlings of each structural element. The proposed corrosion additions are to be not less than the values specified in [3].

2.2.2 Hull girder net strength characteristic calculation

For the hull girder, the net hull transverse sections are to be considered as being constituted by plating and stiffeners having the net scantlings proposed by the Designer.

It is to be checked whether:

$$Z_{NAD} \geq 0,9 Z_{GD}$$

where:

Z_{NAD} : Net midship section modulus, in m^3, calculated on the basis of the net scantlings proposed by the Designer

Z_{GD} : Gross midship section modulus, in m^3, calculated on the basis of the gross scantlings proposed by the Designer.

Where the above condition is not satisfied, the hull girder normal and shear stresses, to be used for the checks of plating, ordinary stiffeners and primary supporting members analysed through an isolated beam structural model, are to be obtained by dividing by 0,9 those obtained by considering the hull girder transverse sections with their gross scantlings.

Table 2 : Corrosion additions t_c, in mm, for one side exposure

Compartment type		General **(1)**	Special cases
Ballast tank **(2)**		1,00	1,25 in upper zone **(6)**
Cargo tank and fuel oil tank **(3)**	Plating of horizontal surfaces	0,75	1,00 in upper zone **(6)**
	Plating of non-horizontal surfaces	0,50	1,00 in upper zone **(6)**
	Ordinary stiffeners	0,75	1,00 in upper zone **(6)**
Cargo tank of ships with service notation **liquefied gas carrier (4)**		0,00	
Dry bulk cargo hold **(5)**	General	1,00	
	Inner bottom plating Side plating for single hull ship Inner side plating for double hull ship Sloping stool plate of hopper tanks and lower stool Transverse bulkhead plating	1,75	
	Frames	1,00	1,50 in lower zone **(7)**
Hopper well of dredging ships		2,00	
Accommodation space		0,00	
Compartments other than those mentioned above Outside sea and air		0,50	

(1) General: corrosion additions t_c are applicable to all members of the considered item with possible exceptions given for upper and lower zones.
(2) Ballast tank: does not include cargo oil tanks which may carry ballast according to Regulation 13 of MARPOL 73/78.
(3) For ships with the service notation **chemical tanker ESP**, the corrosion addition t_C may be taken equal to 0 for cargo tanks covered with a protective lining or coating (see IBC, 6).
For ships with the service notation **tanker**, the corrosion addition t_C may be taken equal to 0 for cargo tanks covered with a protective coating.
(4) The corrosion addition t_C specified for cargo tanks is to be applied when required in IGC, 4.5.2.
(5) Dry bulk cargo hold: includes holds, intended for the carriage of dry bulk cargoes, which may carry oil or water ballast.
(6) Upper zone: area within 1,5 m below the top of the tank or the hold. This is not to be applied to tanks in the double bottom.
(7) Lower zone: area within 3 m above the bottom of the tank or the hold.

3 Corrosion additions

3.1 Values of corrosion additions

3.1.1 General

The values of the corrosion additions specified in this Article are to be applied in relation to the relevant protective coatings required by the Rules.

The Designer may define values of corrosion additions greater than those specified in [3.1.2].

3.1.2 Corrosion additions for steel other than stainless steel

In general, the corrosion addition to be considered for plating forming the boundary between two compartments of different types is the sum of the values specified in Tab 2 for one side exposure to each compartment.

For an internal member within a given compartment, or for plating forming the boundary between two compartments of the same type, the corrosion addition to be considered is twice the value specified in Tab 2 for one side exposure to that compartment.

When, according to Tab 2, a structural element is affected by more than one value of corrosion additions (e.g. a side frame in a dry bulk cargo hold extending above the lower zone), the scantling criteria are generally to be applied considering the value of corrosion addition applicable at the lowest point of the element.

3.1.3 Corrosion additions for stainless steel

For structural members made of stainless steel, the corrosion addition t_c is to be taken equal to 0.

3.1.4 Corrosion additions for non-alloyed steel clad with stainless steel

For plates made of non-alloyed steel clad with stainless steel, the corrosion addition t_c is to be taken equal to 0 only for the plate side clad with stainless steel.

3.1.5 Corrosion additions for aluminium alloys

For structural members made of aluminium alloys, the corrosion addition t_c is to be taken equal to 0.

SECTION 3 STRENGTH PRINCIPLES

Symbols

E : Young's modulus, in N/mm², to be taken equal to:

- for steels in general:

  $E = 2{,}06.10^5$ N/mm²

- for stainless steels:

  $E = 1{,}95.10^5$ N/mm²

- for aluminium alloys:

  $E = 7{,}0.10^4$ N/mm²

s : Spacing, in m, of ordinary stiffeners or primary supporting members, as the case may be

ℓ : Span, in m, of an ordinary stiffener or a primary supporting member, as the case may be, measured between the supporting members (see Fig 2 to Fig 5)

ℓ_b : Length, in m, of brackets (see Fig 4 and Fig 5)

h_w : Web height, in mm, of an ordinary stiffener or a primary supporting member, as the case may be

t_w : Net web thickness, in mm, of an ordinary stiffener or a primary supporting member, as the case may be

b_f : Face plate width, in mm, of an ordinary stiffener or a primary supporting member, as the case may be

t_f : Net face plate thickness, in mm, of an ordinary stiffener or a primary supporting member, as the case may be

t_p : Net thickness, in mm, of the plating attached to an ordinary stiffener or a primary supporting member, as the case may be

w : Net section modulus, in cm³, of an ordinary stiffener or a primary supporting member, as the case may be, with attached plating of width b_p

I : Net moment of inertia, in cm⁴, of an ordinary stiffener or a primary supporting member, as the case may be, without attached plating, around its neutral axis parallel to the plating (see Fig 4 and Fig 5)

I_B : Net moment of inertia, in cm⁴, of an ordinary stiffener or a primary supporting member, as the case may be, with bracket and without attached plating, around its neutral axis parallel to the plating, calculated at mid-length of the bracket (see Fig 4 and Fig 5).

1 General principles

1.1 Structural continuity

1.1.1 The variation in scantlings between the midship region and the fore and aft parts is to be gradual.

1.1.2 Attention is to be paid to the structural continuity:

- in way of changes in the framing system
- at the connections of primary or ordinary stiffeners
- in way of the ends of the fore and aft parts (see Ch 9, Sec 1 and Ch 9, Sec 2) and machinery space (see Ch 9, Sec 3)
- in way of ends of superstructures (see Ch 9, Sec 4).

1.1.3 Longitudinal members contributing to the hull girder longitudinal strength, according to Ch 6, Sec 1, [2], are to extend continuously for a sufficient distance towards the ends of the ship.

Ordinary stiffeners contributing to the hull girder longitudinal strength are generally to be continuous when crossing primary supporting members. Otherwise, the detail of connections is considered by the Society on a case by case basis.

Longitudinals of the bottom, bilge, sheerstrake, deck, upper and lower longitudinal bulkhead and inner side strakes, as well as the latter strakes themselves, the lower strake of the centreline bottom girder and the upper strake of the centreline deck girder, where fitted, are to be continuous through the transverse bulkheads of the cargo area and cofferdams. Alternative solutions may be examined by the Society on a case by case basis, provided they are equally effective.

1.1.4 Where stress concentrations may occur in way of structural discontinuities, adequate compensation and reinforcements are to be provided.

1.1.5 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.

1.1.6 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.

1.2 Connections with higher strength steel

1.2.1 The vertical extent of higher strength steel is to comply with the requirements of Ch 6, Sec 2, [4.5].

1.2.2 *(1/7/2002)*

When a higher strength steel is adopted at deck, members not contributing to the longitudinal strength and welded to the strength deck (e.g. hatch coamings, strengthening of deck openings) are also generally to be made of the same higher strength steel.

1.3 Connections between steel and aluminium

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

1.3.2 Any heterogeneous jointing system is considered by the Society on a case by case basis.

1.3.3 The use of transition joints made of aluminium/steel-clad plates or profiles is considered by the Society on a case by case basis (see Pt D, Ch 3, Sec 2, [4]).

2 Plating

2.1 Insert plates and doublers

2.1.1 A local increase in plating thickness is generally to be achieved through insert plates. Local doublers, which are normally only allowed 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 that of the plates on which they are welded.

2.1.2 Doublers having width, in mm, greater than:

- 20 times their thickness, for thicknesses equal to or less than 15 mm
- 25 times their thickness, for thicknesses greater than 15 mm

are to be fitted with slot welds, to be effected according to Ch 12, Sec 1, [2.6].

2.1.3 When doublers fitted on the outer shell and strength deck within 0,6L 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 [2.1.2]. Outside this area, the possibility of fitting doublers requiring slot welds will be considered by the Society on a case by case basis.

3 Ordinary stiffeners

3.1 General

3.1.1 Stiffener not perpendicular to the attached plating

Where the stiffener is not perpendicular to the attached plating, the actual net section modulus may be obtained, in cm^3, from the following formula:

$$w = w_0 \sin\alpha$$

where:

w_0 : Actual net section modulus, in cm^3, of the stiffener assumed to be perpendicular to the plating

α : Angle between the stiffener web and the attached plating.

3.1.2 Bulb section: equivalent angle profile

A bulb section may be taken as equivalent to an angle profile.

The dimensions of the equivalent angle profile are to be obtained, in mm, from the following formulae:

$$h_w = h'_w - \frac{h'_w}{9,2} + 2$$

$$t_w = t'_w$$

$$b_f = \alpha\left[t'_w + \frac{h'_w}{6,7} - 2\right]$$

$$t_f = \frac{h'_w}{9,2} - 2$$

where:

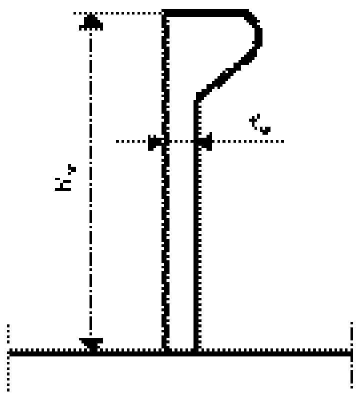
h'_w, t'_w : Height and net thickness of the bulb section, in mm, as shown in Fig 1

α : Coefficient equal to:

$$1,1 + \frac{(120 - h'_w)^2}{3000} \quad \text{for } h'_w \le 120$$

$$1 \quad \text{for } h'_w > 120$$

Figure 1 : Dimensions of a bulb section



3.2 Span of ordinary stiffeners

3.2.1 General

The span ℓ of ordinary stiffeners is to be measured as shown in Fig 2 to Fig 5.

Figure 2 : Ordinary stiffener without brackets

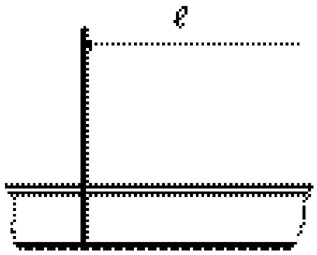


Figure 3 : Ordinary stiffener with a stiffener at one end

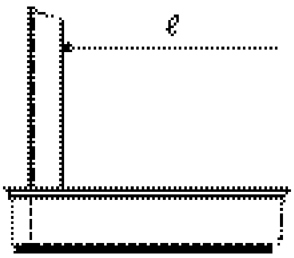


Figure 4 : Ordinary stiffener with end bracket

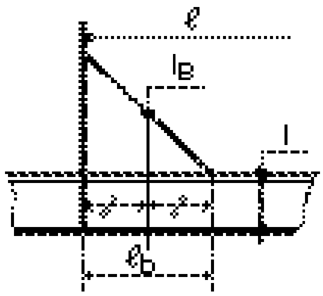
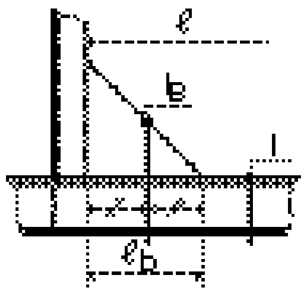


Figure 5 : Ordinary stiffener with a bracket and a stiffener at one end



3.2.2 Open floors

The span ℓ of transverse ordinary stiffeners constituting an open floor is to be taken as the greater of $1,4\ell_1$ and $0,7\ell_2$, where ℓ_1 and ℓ_2 are the spans defined in Fig 6.

3.3 Width of attached plating

3.3.1 Yielding check

The width of the attached plating to be considered for the yielding check of ordinary stiffeners is to be obtained, in m, from the following formulae:

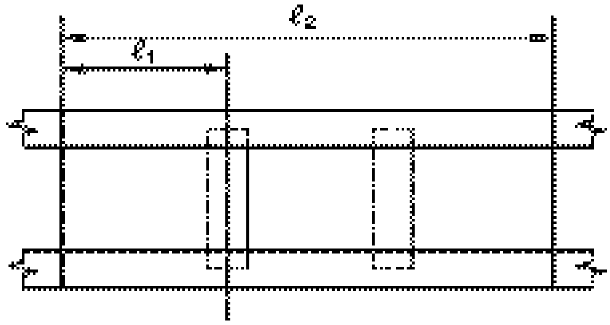
- where the plating extends on both sides of the ordinary stiffener:

  $b_P = s$

- where the plating extends on one side of the ordinary stiffener (i.e. ordinary stiffeners bounding openings):

  $b_P = 0,5s$.

Figure 6 : Span of ordinary stiffeners in the case of open floors



3.3.2 Buckling check and ultimate strength check

The attached plating to be considered for the buckling and ultimate strength check of ordinary stiffeners is defined in Ch 7, Sec 2, [4.1] and Ch 7, Sec 2, [5.2], respectively.

3.4 Geometric properties

3.4.1 Built section

The geometric properties of built sections as shown in Fig 7 may be calculated as indicated in the following formulae. These formulae are applicable provided that:

$A_a \geq t_f b_f$

$\frac{h_w}{t_p} \geq 10$

$\frac{h_w}{t_f} \geq 10$

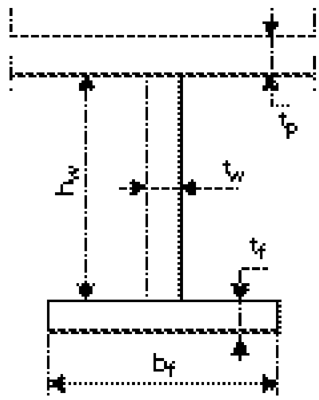
where:

A_a : Net sectional area, in mm^2, of the attached plating.

The net shear sectional area of a built section with attached plating is to be obtained, in cm^2, from the following formula:

$$A_{Sh} = \frac{h_w t_w}{100}$$

Figure 7 : Dimensions of a built section



The net section modulus of a built section with attached plating is to be obtained, in cm³, from the following formula:

$$w = \frac{h_w t_f b_f}{1000} + \frac{t_w h_w^2}{6000}\left(1 + \frac{A_a - t_f b_f}{A_a + \frac{t_w h_w}{2}}\right)$$

The distance from face plate to neutral axis is to be obtained, in cm, from the following formula:

$$v = \frac{h_w (A_a + 0,5 t_w h_w)}{10(A_a + t_f b_f + t_w h_w)}$$

The net moment of inertia of a built section with attached plating is to be obtained, in cm⁴, from the following formula:

$I = w\,v$

3.4.2 Corrugations *(1/7/2002)*

Unless otherwise specified, the net section modulus of a corrugation is to be obtained, in cm³, from the following formula:

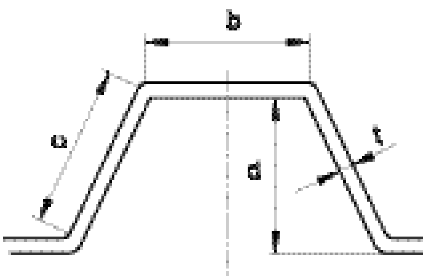
$$w = \frac{td}{6}(3b + c)10^{-3}$$

where:

t : Net thickness of the plating of the corrugation, in mm

d, b, c : Dimensions of the corrugation, in mm, shown in Fig 8.

Figure 8 : Dimensions of a corrugation



At the corrugation ends, where the web continuity is not ensured (e.g. where the corrugation webs are not supported by local brackets) the net section modulus of the corrugation is to be obtained, in cm³, from the following formula:

$$w = 0,5\,btd10^{-3}$$

A more precise calculation of the net section modulus may be carried out taking into account the effectiveness of corrugation webs. In general, the corrugation webs may be considered 30% effective.

3.5 End connections

3.5.1 Where ordinary stiffeners are continuous through primary supporting members, they are to be connected to the web plating so as to ensure proper transmission of loads, e.g. by means of one of the connection details shown in Fig 9 to Fig 12.

Connection details other than those shown in Fig 9 to Fig 12 may be considered by the Society on a case by case basis. In some cases, the Society may require the details to be supported by direct calculations submitted for review.

Figure 9 : End connection of ordinary stiffener Without collar plate

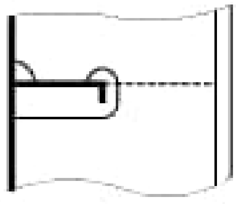


Figure 10 : End connection of ordinary stiffener Collar plate

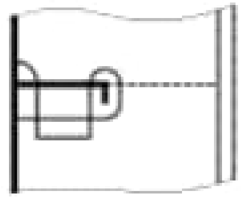


Figure 11 : End connection of ordinary stiffener One large collar plate

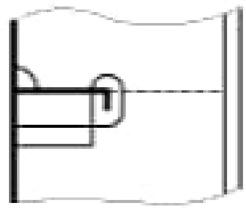
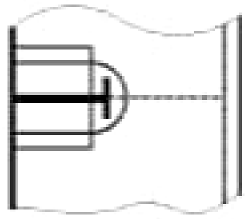


Figure 12 : End connection of ordinary stiffener Two large collar plates

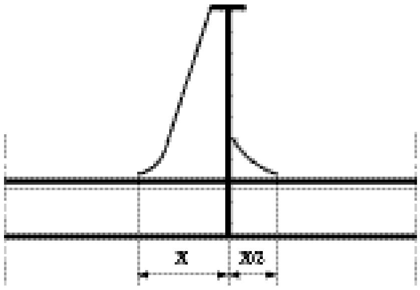


3.5.2 Where ordinary stiffeners are cut at primary supporting members, brackets are to be fitted to ensure the structural continuity. Their net section modulus and their net sectional area are to be not less than those of the ordinary stiffeners.

The net thickness of brackets is to be not less than that of ordinary stiffeners. Brackets with net thickness, in mm, less than $15L_b$, where L_b is the length, in m, of the free edge of the end bracket, are to be flanged or stiffened by a welded face plate. The net sectional area, in cm², of the flanged edge or face plate is to be at least equal to $10L_b$.

3.5.3 Where necessary, the Society may require backing brackets to be fitted, as shown in Fig 13, in order to improve the fatigue strength of the connection (see also [4.7.4]).

Figure 13 : End connection of ordinary stiffener Backing bracket



4 Primary supporting members

4.1 Span of primary supporting members

4.1.1 The span of primary supporting members is to be determined in accordance with [3.2].

4.2 Width of attached plating

4.2.1 General

The width of the attached plating to be considered for the yielding check of primary supporting members analysed through beam structural models is to be obtained, in m, from the following formulae:

- where the plating extends on both sides of the primary supporting member:

  $b_P = \min (s; 0{,}2\ell)$

- where the plating extends on one side of the primary supporting member (i.e. primary supporting members bounding openings):

  $b_P = 0{,}5 \min (s; 0{,}2\ell)$

4.2.2 Corrugated bulkheads

The width of attached plating of corrugated bulkhead primary supporting members is to be determined as follows:

- when primary supporting members are parallel to the corrugations and are welded to the corrugation flanges, the width of the attached plating is to be calculated in accordance with [4.2.1] and is to be taken not greater than the corrugation flange width
- when primary supporting members are perpendicular to the corrugations, the width of the attached plating is to be taken equal to the width of the primary supporting member face plate.

4.3 Geometric properties

4.3.1 Standard roll sections

The geometric properties of primary supporting members made of standard roll sections may be determined in accordance with [3.4.1].

4.3.2 Built sections

The geometric properties of primary supporting members made of built sections (including primary supporting members of double skin structures, such as double bottom floors and girders) are generally determined in accordance with [3.4.1].

Additional requirements relevant to the net shear sectional area are provided in [4.3.3].

4.3.3 Net shear sectional area in the case of web large openings

Where large openings are fitted in the web of primary supporting members (e.g. where a pipe tunnel is fitted in the double bottom, see Fig 14), their influence is to be taken into account by assigning an equivalent net shear sectional area to the primary supporting member.

This equivalent net shear sectional area is to be obtained, in cm², from the following formula:

$$A_{Sh} = \frac{A_{Sh1}}{1 + \dfrac{0{,}0032\,\ell^2 A_{Sh1}}{I_1}} + \frac{A_{Sh2}}{1 + \dfrac{0{,}0032\,\ell^2 A_{Sh2}}{I_2}}$$

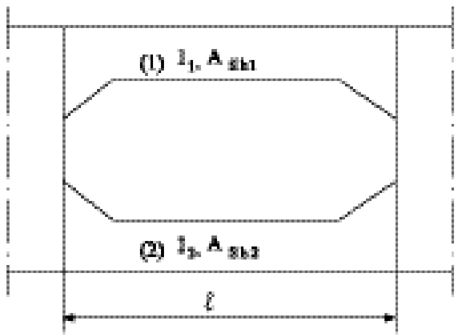
where (see Fig 14):

I_1, I_2 : Net moments of inertia, in cm⁴, of deep webs (1) and (2), respectively, with attached plating around their neutral axes parallel to the plating

A_{Sh1}, A_{Sh2} : Net shear sectional areas, in cm², of deep webs (1) and (2), respectively, to be calculated according to [4.3.2]

ℓ : Span, in cm, of deep webs (1) and (2).

Figure 14 : Large openings in the web of primary supporting members



4.4 Bracketed end connections

4.4.1 Arm lengths of end brackets are to be equal, as far as practicable.

With the exception of primary supporting members of transversely framed single sides (see Sec 5, [3.2]), the height of end brackets is to be not less than that of the primary supporting member.

4.4.2 The net thickness of the end bracket web is generally to be not less than that of the primary supporting member web.

4.4.3 The net scantlings of end brackets are generally to be such that the net section modulus of the primary supporting member with end brackets is not less than that of the primary supporting member at mid-span.

4.4.4 The width, in mm, of the face plate of end brackets is to be not less than $50(L_b+1)$, where L_b is the length, in m, of the free edge of the end bracket.

Moreover, the net thickness of the face plate is to be not less than that of the bracket web.

4.4.5 Stiffening of end brackets is to be designed such that it provides adequate buckling web stability.

As guidance, the following prescriptions may be applied:

- where the length L_b is greater than 1,5 m, the web of the bracket is to be stiffened
- the net sectional area, in cm^2, of web stiffeners is to be not less than $16,5\ell$, where ℓ is the span, in m, of the stiffener
- tripping flat bars are to be fitted to prevent lateral buckling of web stiffeners. Where the width of the symmetrical face plate is greater than 400 mm, additional backing brackets are to be fitted.

4.4.6 In addition to the above requirements, the net scantlings of end brackets are to comply with the applicable requirements given in Sec 4 to Sec 7.

4.5 Bracketless end connections

4.5.1 In the case of bracketless crossing between primary supporting members (see Fig 15), the net thickness of the common part of the web is to be not less than the value obtained, in mm, from the following formula:

$$t = 15,75\frac{w}{\Omega}$$

where:

- w : the lesser of w_1 and $w_{2,MAX}$
- w_1 : gross section modulus, in cm^3, of member 1
- $w_{2,MAX}$: the greater value, in cm^3, of the gross section moduli of members 2 and 3
- Ω : Area, in cm^2, of the common part of members 1, 2 and 3.

In the absence of one of members 2 and 3 shown in Fig 15, the value of the relevant gross section modulus is to be taken equal to zero.

4.5.2 In no case may the net thickness calculated according to [4.5.1] be less than the smallest web net thickness of the members forming the crossing.

4.5.3 In general, the continuity of the face plates is to be ensured.

4.6 Cut-outs and holes

4.6.1 Cut-outs for the passage of ordinary stiffeners are to be as small as possible and well rounded with smooth edges.

In general, the depth of cut-outs is to be not greater than 50% of the depth of the primary supporting member.

4.6.2 Where openings such as lightening holes are cut in primary supporting members, they are to be equidistant from the face plate and corners of cut-outs and, in general, their height is to be not greater than 20% of the web height.

4.6.3 Openings may not be fitted in way of toes of end brackets.

Figure 15 : Bracketless end connections of primary supporting members

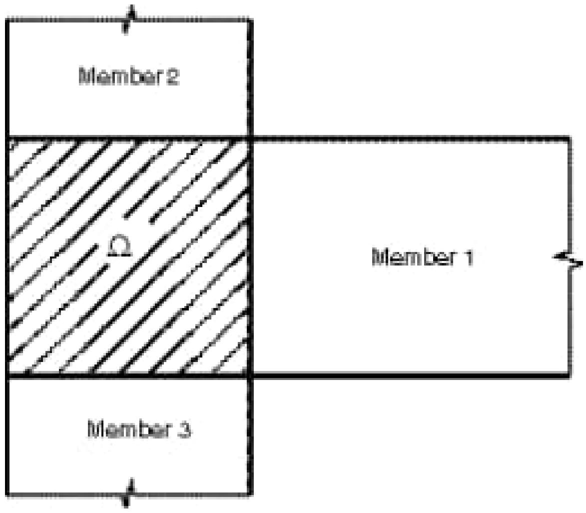
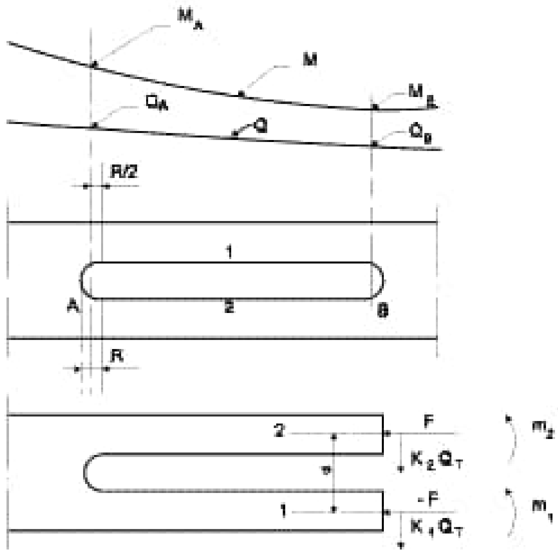


Figure 16 : Large openings in primary supporting members - Secondary stresses



4.6.4 Over half of the span of primary supporting members, the length of openings is to be not greater than the distance between adjacent openings.

At the ends of the span, the length of openings is to be not greater than 25% of the distance between adjacent openings.

4.6.5 In the case of large openings as shown in Fig 16, the secondary stresses in primary supporting members are to be considered for the reinforcement of the openings.

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:

$$F = \frac{M_A + M_B}{2d}$$

$$m_1 = \left|\frac{M_A - M_B}{2}\right| K_1$$

$$m_2 = \left|\frac{M_A - M_B}{2}\right| K_2$$

$$\sigma_{F1} = 10\frac{F}{S_1}$$

$$\sigma_{F2} = 10\frac{F}{S_2}$$

$$\sigma_{m1} = \frac{m_1}{w_1}10^3$$

$$\sigma_{m2} = \frac{m_2}{w_2}10^3$$

$$\tau_1 = 10\frac{K_1 Q_T}{S_{w1}}$$

$$\tau_2 = 10\frac{K_2 Q_T}{S_{w2}}$$

where:

M_A, M_B : Bending moments, in kN.m, in sections A and B of the primary supporting member

m_1, m_2 : Bending moments, in kN.m, in (1) and (2)

d : Distance, in m, between the neutral axes of (1) and (2)

σ_{F1}, σ_{F2} : Axial stresses, in N/mm^2, in (1) and (2)

σ_{m1}, σ_{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

τ_1, τ_2 : Shear stresses, in N/mm^2, in (1) and (2)

w_1, w_2 : Net section moduli, in cm^3, of (1) and (2)

S_1, S_2 : Net sectional areas, in cm^2, of (1) and (2)

S_{w1}, S_{w2} : Net sectional areas, in cm^2, of webs in (1) and (2)

I_1, I_2 : Net 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 σ_C calculated at the ends of members (1) and (2) is to be obtained from the following formula:

$$\sigma_c = \sqrt{(\sigma_F + \sigma_m)^2 + 3\tau^2}$$

The combined stress σ_C is to comply with the checking criteria in Ch 7, Sec 3, [3.6] or Ch 7, Sec 3, [4.3], as applicable. Where these checking criteria are not complied with, the cut-out is to be reinforced according to one of the solutions shown in Fig 17 to Fig 19:

- continuous face plate (solution 1): see Fig 17
- straight face plate (solution 2): see Fig 18
- compensation of the opening (solution 3): see Fig 19
- combination of the above solutions.

Other arrangements may be accepted provided they are supported by direct calculations submitted to the Society for review.

Figure 17 : Stiffening of large openings in primary supporting members - Solution 1

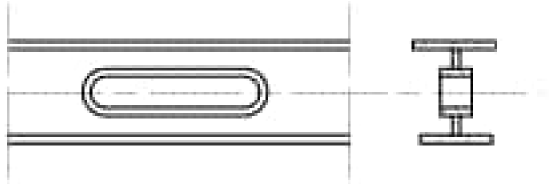


Figure 18 : Stiffening of large openings in primary supporting members - Solution 2

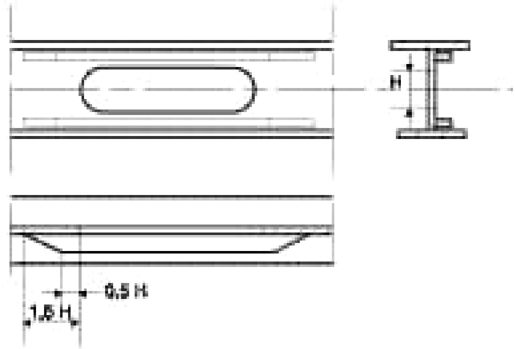
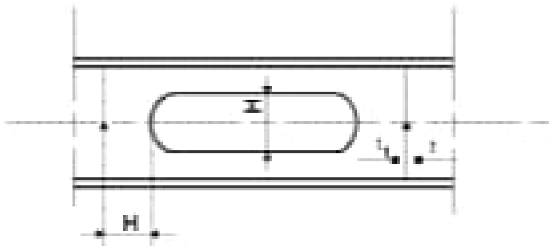


Figure 19 : Stiffening of large openings in primary supporting members - Solution 3

Inserted plate



4.7 Stiffening arrangement

4.7.1 Webs of primary supporting members are generally to be stiffened where the height, in mm, is greater than 100t, where t is the web net thickness, in mm, of the primary supporting member.

In general, the web stiffeners of primary supporting members are to be spaced not more than 110t.

4.7.2 Where primary supporting member web stiffeners are welded to ordinary stiffener face plates, their net sectional area at the web stiffener mid-height is to be not less than the value obtained, in cm^2, from the following formula:

$$A = 0{,}1 k_1 (\gamma_{S2} p_S + \gamma_{W2} p_W) s \ell$$

where:

k_1 : Coefficient depending on the web connection with the ordinary stiffener, to be taken as:

- k_1 = 0,3 for connections without collar plate (see Fig 9)
- k_1 = 0,225 for connections with a collar plate (see Fig 10)
- k_1 = 0,2 for connections with one or two large collar plates (see Fig 11 and Fig 12)

p_S, p_W : Still water and wave pressure, respectively, in kN/m², acting on the ordinary stiffener, defined in Ch 7, Sec 2, [3.3.2] or Ch 8, Sec 4, [3.3.2]

γ_{S2}, γ_{W2} : Partial safety factors, defined in Ch 7, Sec 2, Tab 1 or Ch 8, Sec 4, Tab 1 for yielding check (general).

4.7.3 The net section modulus of web stiffeners of non-watertight primary supporting members is to be not less than the value obtained, in cm³, from the following formula:

$$w = 2{,}5s^2tS_s^2$$

where:

s : Length, in m, of web stiffeners

t : Web net thickness, in mm, of the primary supporting member

S_s : Spacing, in m, of web stiffeners.

Moreover, web stiffeners located in areas subject to compression stresses are to be checked for buckling in accordance with Ch 7, Sec 2, [4].

4.7.4 Tripping brackets (see Fig 20) welded to the face plate are generally to be fitted:

- every fourth spacing of ordinary stiffeners, without exceeding 4 m
- 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.

4.7.5 In general, the width of the primary supporting member face plate is to be not less than one tenth of the depth of the web, where tripping brackets are spaced as specified in [4.7.4].

4.7.6 The arm length of tripping brackets is to be not less than the greater of the following values, in m:

$$d = 0{,}38b$$

$$d = 0{,}85b\sqrt{\frac{s_t}{t}}$$

where:

b : Height, in m, of tripping brackets, shown in Fig 20

s_t : Spacing, in m, of tripping brackets

t : Net thickness, in mm, of tripping brackets.

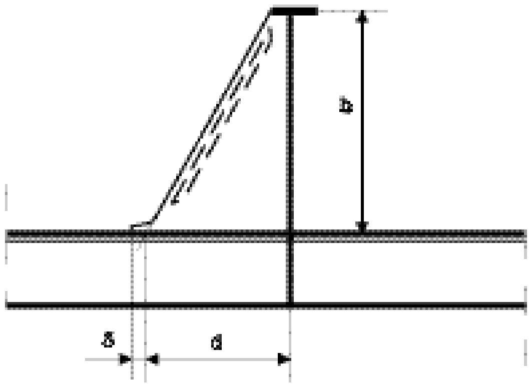
It is recommended that the bracket toe should be designed as shown in Fig 20.

4.7.7 Tripping brackets with a net thickness, in mm, less than $15L_b$ are to be flanged or stiffened by a welded face plate.

The net sectional area, in cm², of the flanged edge or the face plate is to be not less than $10L_b$, where L_b is the length, in m, of the free edge of the bracket.

Where the depth of tripping brackets is greater than 3 m, an additional stiffener is to be fitted parallel to the bracket free edge.

Figure 20 : Primary supporting member: web stiffener in way of ordinary stiffener



SECTION 4 BOTTOM STRUCTURE

1 General

1.1 Application

1.1.1 The requirements of this Section apply to longitudinally or transversely framed single and double bottom structures.

1.2 General arrangement

1.2.1 In ships greater than 120 m in length, the bottom is, in general, to be longitudinally framed.

1.2.2 *(1/7/2002)*

The bottom is to be checked by the Designer to ascertain that it withstands the loads resulting from the dry-docking of the ship.

1.2.3 The bottom is to be locally stiffened where concentrated loads are envisaged.

1.2.4 Girders or floors are to be fitted under each line of pillars, when deemed necessary by the Society on the basis of the loads carried by the pillars.

1.2.5 Adequate tapering is to be provided between double bottom and adjacent single bottom structures. Similarly, adequate continuity is to be provided in the case of height variation in the double bottom. Where such a height variation occurs within 0,6 L amidships, the inner bottom is generally to be maintained continuous by means of inclined plating.

1.2.6 Provision is to be made for the free passage of water from all parts of the bottom to the suctions, taking into account the pumping rate required.

1.2.7 When solid ballast is fitted, it is to be securely positioned. If necessary, intermediate floors may be required for this purpose.

1.3 Keel

1.3.1 The width of the keel is to be not less than the value obtained, in m, from the following formula:

$$b = 0,8 + 0,5\frac{L}{100}$$

1.4 Drainage and openings for air passage

1.4.1 Holes are to be cut into floors and girders to ensure the free passage of air and liquids from all parts of the double bottom.

1.4.2 Air holes are to be cut as near to the inner bottom and draining holes as near to the bottom shell as practicable.

2 Longitudinally framed single bottom

2.1 General

2.1.1 Single bottom ships are to be fitted with a centre girder formed by a vertical continuous or intercostal web plate and a horizontal face plate continuous over the floors.

Intercostal web plates are to be aligned and welded to floors.

2.1.2 In general, girders are to be fitted spaced not more than 2,5 m apart and formed by a vertical intercostal web plate and a horizontal face plate continuous over the floors.

Intercostal web plates are to be aligned and welded to floors.

2.1.3 Centre and side girders are to be extended as far aft and forward as practicable.

2.1.4 Where side girders are fitted in lieu of the centre girder, the scarfing is to be adequately extended and additional stiffening of the centre bottom may be required.

2.1.5 Longitudinal girders are to be fitted in way of each line of pillars.

2.1.6 Floors are to be made with a welded face plate between the collision bulkhead and 0,25L from the fore end.

2.2 Floors

2.2.1 In general, the floor spacing is to be not greater than 5 frame spacings.

2.3 Longitudinal ordinary stiffeners

2.3.1 Longitudinal ordinary stiffeners are generally to be continuous when crossing primary members.

3 Transversely framed single bottom

3.1 General

3.1.1 The requirements in [2.1] apply also to transversely framed single bottoms.

3.2 Floors

3.2.1 Floors are to be fitted at every frame.

3.2.2 The height, in m, of floors at the centreline is to be not less than B/16. In the case of ships with considerable rise of floor, this height may be required to be increased so as to assure a satisfactory connection to the frames.

4 Longitudinally framed double bottom

4.1 General

4.1.1 The centre girder is to be continuous and extended over the full length of ship and the spacing of adjacent longitudinal girders is generally to be not greater than 6,5 m.

4.2 Double bottom height

4.2.1 The double bottom height is to be sufficient to ensure access to all parts and, in way of the centre girder, is to be not less than the greater value obtained, in m, from the following formulae:

$$h_{DB} = 3\frac{B+T+10}{100}$$

$$h_{DB} = 0,7$$

4.2.2 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 plate floors.

Where this is impossible, suitable longitudinal structures such as partial girders, longitudinal brackets etc., fitted across the knuckle are to be arranged.

4.2.3 In ships without a flat bottom, the height of double bottom specified in [4.2.1] may be required to be adequately increased such as to ensure sufficient access to the areas towards the sides.

4.3 Floors

4.3.1 The spacing of plate floors, in m, is generally to be not greater than 0,05L or 3,8 m, whichever is the lesser.

Additional plate floors are to be fitted in way of transverse watertight bulkheads.

4.3.2 Plate floors are generally to be provided with stiffeners in way of longitudinal ordinary stiffeners.

4.3.3 Where the double bottom height exceeds 0,9 m, watertight floors are to be fitted with stiffeners having a net section modulus not less than that required for tank bulkhead vertical stiffeners.

4.4 Bottom and inner bottom longitudinal ordinary stiffeners

4.4.1 Bottom and inner bottom longitudinal ordinary stiffeners are generally to be continuous through the floors.

4.5 Brackets to centreline girder and margin plate

4.5.1 In general, intermediate brackets are to be fitted connecting either the margin plate or the centre girder to the nearest bottom and inner bottom ordinary stiffeners.

4.5.2 Such brackets are to be stiffened at the edge with a flange having a width not less than 1/10 of the local double bottom height.

If necessary, the Society may require a welded flat bar to be arranged in lieu of the flange.

4.5.3 Where the side shell is transversely stiffened, margin plate brackets are to be fitted at every frame.

4.6 Duct keel

4.6.1 Where a duct keel is arranged, the centre girder may be replaced by two girders conveniently spaced, generally no more than 2 m apart.

4.6.2 The structures in way of the floors are to ensure sufficient continuity of the latter.

4.7 Bilge wells

4.7.1 Bilge wells arranged in the double bottom are to be limited in depth and formed by steel plates having a net thickness not less than the greater of that required for watertight floors and that required for the inner bottom.

4.7.2 *(1/1/2024)*

Vertical extension of bilge wells is to comply with the requirements given in Ch 2, Sec 2, [3.1.1].

4.7.3 Where there is no margin plate, well arrangement is considered by the Society on a case by case basis.

5 Transversely framed double bottom

5.1 General

5.1.1 The requirements in [4.1], [4.2], [4.5], [4.6] and [4.7] apply also to transversely framed double bottoms.

5.2 Floors

5.2.1 Plate floors are to be fitted at every frame forward of 0,75L from the aft end.

Plate floors are also to be fitted:

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

Elsewhere, plate floors may be arranged at a distance not exceeding 3 m.

5.2.2 In general, plate floors are to be continuous between the centre girder and the margin plate.

5.2.3 Open floors are to be fitted in way of intermediate frames.

5.2.4 Where the double bottom height exceeds 0,9 m, plate floors are to be fitted with vertical stiffeners spaced not more than 1,5 m apart.

These stiffeners may consist of flat bars with a width equal to one tenth of the floor depth and a net thickness, in mm, not less than $0,8L^{0,5}$.

5.3 Girders

5.3.1 Side girders are to be arranged in such a way that their distance to adjacent girders or margin plate does not generally exceed 4,5 m.

5.3.2 Where the double bottom height exceeds 0,9 m, longitudinal girders are to be fitted with vertical stiffeners spaced not more than 1,5 m apart.

These stiffeners may consist of flat bars with a width equal to one tenth of the girder height and a net thickness, in mm, not less than $0,8L^{0,5}$.

5.3.3 In way of open floors, side girders are to be provided with stiffeners having a web height which is generally to be not less than 150 mm.

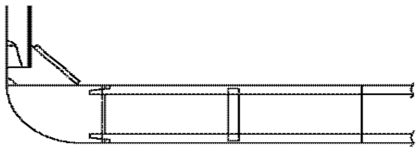
5.4 Open floors

5.4.1 At each frame between plate floors, open floors are to be arranged consisting of a frame connected to the bottom plating and a reverse frame connected to the inner bottom plating (See Fig 1).

5.4.2 Open floors are to be attached to the centreline girder and to the margin plate by means of flanged brackets having a width of flange not less than 1/10 of the local double bottom height.

5.4.3 Where frames and reverse frames are interrupted in way of girders, double brackets are to be fitted.

Figure 1 : Open floor



6 Bilge keel

6.1 Arrangement, scantlings and connections

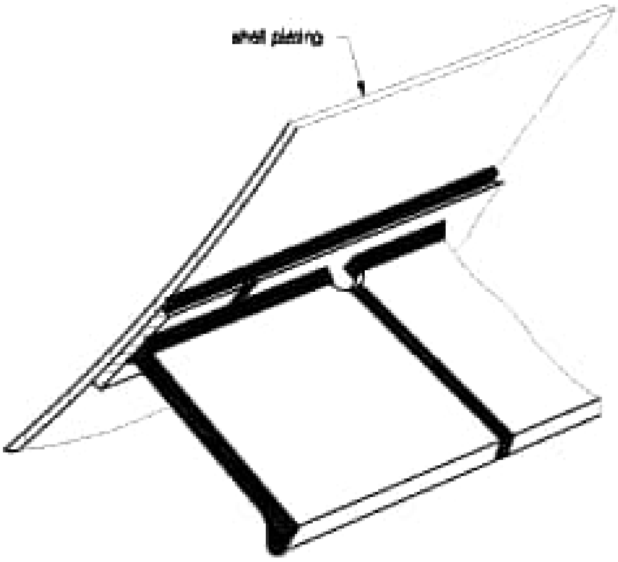
6.1.1 Arrangement

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

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

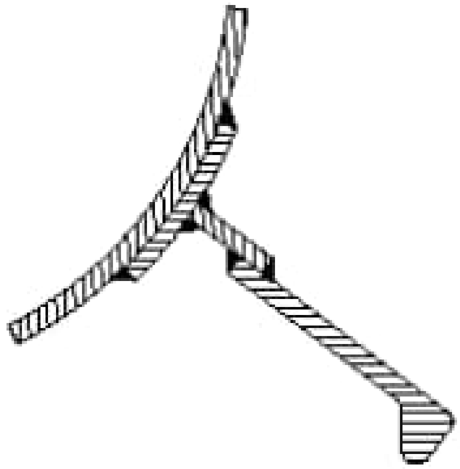
The arrangement shown in Fig 2 is recommended.

Figure 2 : Bilge keel arrangement



The arrangement shown in Fig 3 may also be accepted.

Figure 3 : Bilge keel arrangement



6.1.2 Materials

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

6.1.3 Scantlings

The net thickness of the intermediate flat is to be equal to that of the bilge strake. However, this thickness may generally not be greater than 15 mm.

6.1.4 Welding

Welding of bilge keel and intermediate plate connections is to be in accordance with Ch 12, Sec 1, [3.2].

SECTION 5 SIDE STRUCTURE

1 General

1.1 Application

1.1.1 The requirements of this Section apply to longitudinally or transversely framed single and double side structures.

1.1.2 The transversely framed side structures are built with transverse frames possibly supported by side girders (see [5.3.1]).

1.1.3 The longitudinally framed side structures are built with longitudinal ordinary stiffeners supported by side vertical primary supporting members.

1.2 General arrangement

1.2.1 Unless otherwise specified, side girders are to be fitted aft of the collision bulkhead up to 0,2L aft of the fore end, in line with fore peak girders.

1.2.2 Side vertical primary supporting members are to be fitted in way of hatch end beams.

1.3 Sheerstrake

1.3.1 *(1/7/2002)*
The width of the sheerstrake is to be not less than the value obtained, in m, from the following formula:

$$b = 0{,}715 + 0{,}425\frac{L}{100}$$

However, the sheerstrake is also to comply with the requirements in Sec 1, [2.5.5].

1.3.2 The sheerstrake may be either welded to the stringer plate or rounded. If it is rounded, the radius, in mm, is to be not less than $17t_S$, where t_S is the net thickness, in mm, of the sheerstrake.

1.3.3 The upper edge of the welded sheerstrake is to be rounded and free of notches.

1.3.4 The transition from a rounded sheerstrake to an angled sheerstrake associated with the arrangement of superstructures at the ends of the ship is to be carefully designed so as to avoid any discontinuities.

Plans showing details of this transition are to be submitted for approval to the Society.

2 Longitudinally framed single side

2.1 Longitudinal ordinary stiffeners

2.1.1 Longitudinal ordinary stiffeners are generally to be continuous when crossing primary members.

2.2 Primary supporting members

2.2.1 In general, the side vertical primary supporting member spacing may not exceed 5 frame spacings.

2.2.2 In general, the side vertical primary supporting members are to be bracketed to the double bottom transverse floors.

3 Transversely framed single side

3.1 Frames

3.1.1 Transverse frames are to be fitted at every frame.

3.1.2 Frames are generally to be continuous when crossing primary members.

Otherwise, the detail of the connection is to be examined by the Society on a case by case basis.

3.1.3 In general, the net section modulus of 'tween deck frames is to be not less than that required for frames located immediately above.

3.2 Primary supporting members

3.2.1 In 'tweendecks of more than 4 m in height, side girders or side vertical primary supporting members or both may be required by the Society.

3.2.2 Side girders are to be flanged or stiffened by a welded face plate.

The width of the flanged edge or face plate is to be not less than 22t, where t is the web net thickness, in mm, of the girder.

3.2.3 The height of end brackets is to be not less than half the height of the primary supporting member.

4 Longitudinally framed double side

4.1 General

4.1.1 Adequate continuity of strength is to be ensured in way of breaks or changes in width of the double side.

In particular, scarfing of the inner side is to be ensured beyond the cargo hold region.

4.1.2 Knuckles of the inner side are to be adequately stiffened by longitudinal stiffeners. Equivalent arrangement may be considered by the Society on a case by case basis.

4.2 Primary supporting members

4.2.1 The height of side vertical primary supporting members may be gradually tapered from bottom to deck. The maximum acceptable taper, however, is 8 cm per metre.

4.2.2 Side vertical primary supporting members supported by a strut and two diagonals converging on the former are to be considered by the Society on a case by case basis.

5 Transversely framed double side

5.1 General

5.1.1 The requirements in [4.1] also apply to transversely framed double side.

5.1.2 Transverse frames may be connected to the vertical ordinary stiffeners of the inner side by means of struts.

Struts are generally to be connected to transverse frames and vertical ordinary stiffeners of the inner side by means of vertical brackets.

5.2 Frames

5.2.1 Transverse frames are to be fitted at every frame.

5.3 Primary supporting members

5.3.1 Unless otherwise specified, transverse frames are to be supported by side girders if $D \geq 6$ m.

These girders are to be supported by side vertical primary supporting members spaced no more than 3,8 m apart.

5.3.2 In the case of ships having $4,5 < D < 6$ m, side vertical primary supporting members are to be fitted, in general not more than 5 frame spacings apart.

6 Frame connections

6.1 General

6.1.1 End connections of frames are to be bracketed.

6.1.2 'Tweendeck frames are to be bracketed at the top and welded or bracketed at the bottom to the deck.

In the case of bulb profiles, a bracket may be required to be fitted at bottom.

6.1.3 Brackets are normally connected to frames by lap welds. The length of overlap is to be not less than the depth of frames.

6.2 Upper brackets of frames

6.2.1 The arm length of upper brackets connecting frames to deck beams is to be not less than the value obtained, in mm, from the following formula:

$$d = \varphi \sqrt{\frac{w + 30}{t}}$$

where:

φ : coefficient equal to:

- for unflanged brackets:

  $\varphi = 48$

- for flanged brackets:

  $\varphi = 43,5$

w : required net section modulus of the stiffener, in cm^3, given in [6.2.2] and [6.2.3] and depending on the type of connection,

t : bracket net thickness, in mm.

6.2.2 For connections of perpendicular stiffeners located in the same plane (see Fig 1) or connections of stiffeners located in perpendicular planes (see Fig 2), the required net section modulus is to be taken equal to:

$w = w_2$ if $w_2 \leq w_1$

$w = w_1$ if $w_2 > w_1$

where w_1 and w_2 are the required net section moduli of stiffeners, as shown in Fig 1 and Fig 2.

Figure 1 : Connections of perpendicular stiffeners in the same plane

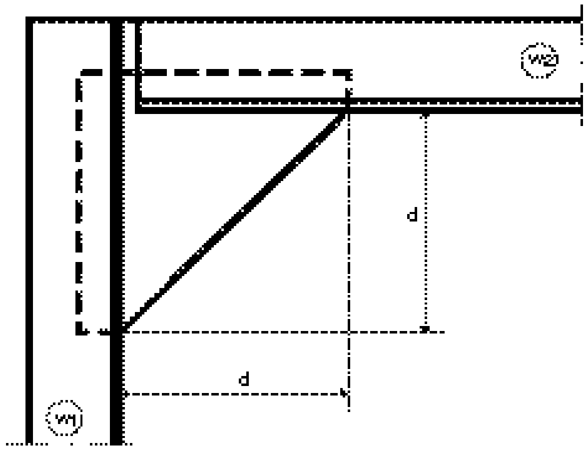
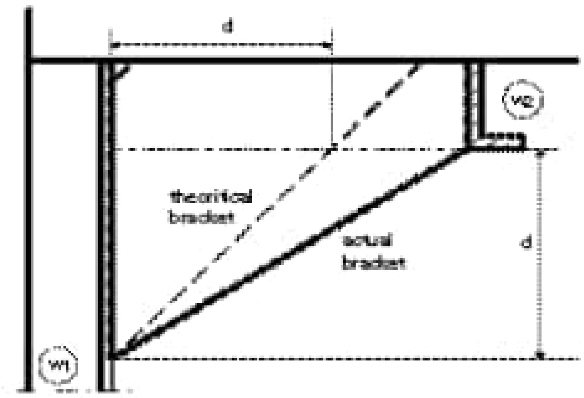


Figure 2 : Connections of stiffeners located in perpendicular planes



6.2.3 For connections of frames to deck beams (see Fig 3), the required net section modulus is to be taken equal to:

- for bracket "A":

$w_A = w_1$ if $w_2 \le w_1$

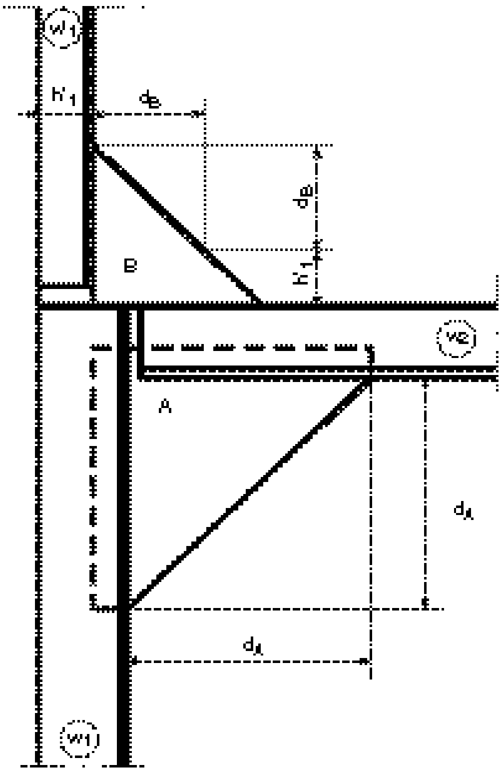
$w_A = w_2$ if $w_2 > w_1$

- for bracket "B":

$w_B = w'_1$ need not be greater than w_1

where w_1, w'_1 and w_2 are the required net section moduli of stiffeners, as shown in Fig 3.

Figure 3 : Connections of frames to deck beams



6.3 Lower brackets of frames

6.3.1 In general, frames are to be bracketed to the inner bottom or to the face plate of floors as shown in Fig 4.

6.3.2 The arm lengths d_1 and d_2 of lower brackets of frames are to be not less than the value obtained, in mm, from the following formula:

$$d = \varphi\sqrt{\frac{w+30}{t}}$$

where:

φ : coefficient equal to:

- for unflanged brackets:

  $\varphi = 50$

- for flanged brackets:

  $\varphi = 45$

w : required net section modulus of the frame, in cm^3,

t : Bracket net thickness, in mm.

6.3.3 Where the bracket net thickness, in mm, is less than $15L_b$, where L_b is the length, in m, of the bracket free edge, the free edge of the bracket is to be flanged or stiffened by a welded face plate.

The net sectional area, in cm^2, of the flange or the face plate is to be not less than $10L_b$.

7 Openings in the shell plating

7.1 Position of openings

7.1.1 Openings in the shell plating are to be located at a vertical distance from the decks at side not less than:

- two times the opening diameter, in case of circular opening
- the opening minor axis, in case of elliptical openings.

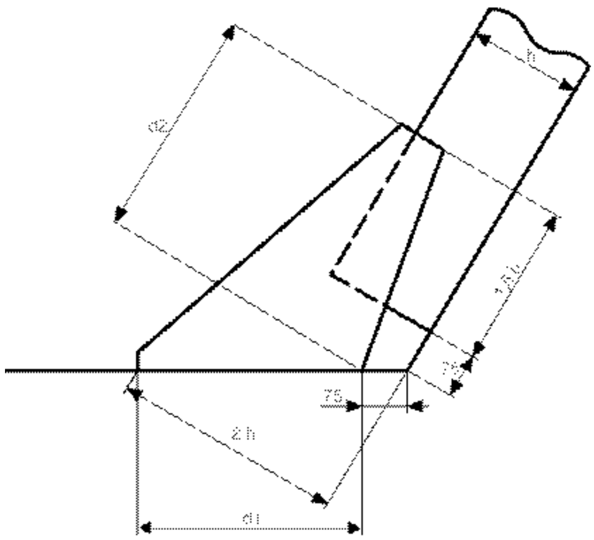
See also Sec 6, Fig 1.

7.2 Local strengthening

7.2.1 Openings in the ship sides, e.g. for cargo ports, are to be well rounded at the corners and located well clear of superstructure ends or any openings in the deck areas at sides of hatchways.

7.2.2 Openings for sea intakes are to be well rounded at the corners and, within 0,6 L amidships, located outside the bilge strakes. Where arrangements are such that sea intakes are unavoidably located in the curved zone of the bilge strakes, such openings are to be elliptical with the major axis in the longitudinal direction. Openings for stabiliser fins are considered by the Society on a case by case basis. The thickness of sea chests is generally to be that of the local shell plating, but in no case less than 12 mm.

Figure 4 : Lower brackets of main frames



7.2.3 Openings in [7.2.1] and [7.2.2] and, when deemed necessary by the Society, other openings of considerable size are to be adequately compensated by means of insert plates of increased thickness or doublers sufficiently extended in length. Such compensation is to be partial or total depending on the stresses occurring in the area of the openings.

Circular openings on the sheerstrake need not be compensated where their diameter does not exceed 20% of the sheerstrake minimum width, defined in [1.3], or 380 mm, whichever is the lesser, and where they are located away from openings on deck at the side of hatchways or superstructure ends.

SECTION 6 DECK STRUCTURE

1 General

1.1 Application

1.1.1 The requirements of this Section apply to longitudinally or transversely framed deck structures.

1.2 General arrangement

1.2.1 The deck supporting structure consists of ordinary stiffeners (beams or longitudinals), longitudinally or transversely arranged, supported by primary supporting members which may be sustained by pillars.

1.2.2 Where beams are fitted in a hatched deck, these are to be effectively supported by at least two longitudinal girders located in way of hatch side girders to which they are to be connected by brackets and/or clips.

1.2.3 In ships greater than 120 m in length, the zones outside the line of openings of the strength deck and other decks contributing to longitudinal strength are, in general, to be longitudinally framed.

Where a transverse framing type is adopted for such ships, it is considered by the Society on a case by case basis.

1.2.4 Adequate continuity of strength is to be ensured in way of:

- stepped strength decks
- changes in the framing system.

Details of structural arrangements are to be submitted for review to the Society.

1.2.5 Where applicable, deck transverses of reinforced scantlings are to be aligned with floors.

1.2.6 Inside the line of openings, a transverse structure is generally to be adopted for cross-deck structures, beams are to be adequately supported by girders and, in ships greater than 120 m in length, extend up to the second longitudinal from the hatch side girders toward the bulwark.

Where this is impracticable, intercostal stiffeners are to be fitted between the hatch side girder and the second longitudinal.

Other structural arrangements may be accepted, subject to their strength verification. In particular, their buckling strength against the transverse compression loads is to be checked. Where needed, deck transverses may be required to be fitted.

1.2.7 Deck supporting structures under deck machinery, cranes and king posts are to be adequately stiffened.

1.2.8 Pillars or other supporting structures are generally to be fitted under heavy concentrated cargoes.

1.2.9 Special arrangements, such as girders supported by cantilevers, are considered by the Society on a case by case basis.

1.2.10 Where devices for vehicle lashing arrangements and/or corner fittings for containers are directly attached to deck plating, provision is to be made for the fitting of suitable additional reinforcements of the sizes required by the load carried.

1.2.11 Stiffeners are also to be fitted in way of the ends and corners of deck houses and partial superstructures.

1.3 Construction of watertight decks

1.3.1 *Watertight decks are to be of the same strength as watertight bulkheads at corresponding levels. The means used for making them watertight, and the arrangements adopted for closing openings in them, are to be to the satisfaction of the Society.*

1.4 Stringer plate

1.4.1 The width of the stringer plate is to be not less than the value obtained, in m, from the following formula:

$$b = 0{,}35 + 0{,}5\frac{L}{100}$$

However, the stringer plate is also to comply with the requirements in Sec 1, [2.5.5].

1.4.2 Stringer plates of lower decks not extending over the full ship's length are to be gradually tapered or overlapped by adequately sized brackets.

2 Longitudinally framed deck

2.1 General

2.1.1 Deck longitudinals are to be continuous, as far as practicable, in way of deck transverses and transverse bulkheads.

Other arrangements may be considered, provided adequate continuity of longitudinal strength is ensured.

2.1.2 In general, the spacing of deck transverses is not to exceed 5 frame spacings.

2.2 Longitudinal ordinary stiffeners

2.2.1 In ships equal to or greater than 120 m in length, strength deck longitudinal ordinary stiffeners are to be continuous through the watertight bulkheads and/or deck transverses.

2.2.2 Frame brackets, in ships with transversely framed sides, are generally to have their horizontal arm extended to the adjacent longitudinal ordinary stiffener.

3 Transversely framed deck

3.1 General

3.1.1 In general, deck beams are to be fitted at each frame.

4 Pillars

4.1 General

4.1.1 Pillars are to be fitted, as far as practicable, in the same vertical line.

4.1.2 In general, pillars are to be fitted below winches, cranes, windlasses and steering gear, in the engine room and at the corners of deckhouses.

4.1.3 In tanks, solid or open section pillars are generally to be fitted. Pillars located in spaces intended for products which may produce explosive gases are to be of open section type.

4.1.4 Tight or non-tight bulkheads may be considered as pillars, provided that their arrangement complies with Sec 7, [4].

4.2 Connections

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

Insert plates may be replaced by doubling plates, except in the case of pillars which may also work under tension such as those in tanks.

In general, the net thickness of doubling plates is to be not less than 1,5 times the net thickness of the pillar.

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

4.2.3 Pillars are to be connected to the inner bottom at the intersection of girders and floors.

4.2.4 Where pillars connected to the inner bottom are not located in way of intersections of floors and girders, partial floors or girders or equivalent structures suitable to support the pillars are to be arranged.

4.2.5 Manholes may not be cut in the girders and floors below the heels of pillars.

4.2.6 Where pillars are fitted in tanks, head and heel brackets may be required if tensile stresses are expected.

4.2.7 Where side pillars are not fitted in way of hatch ends, vertical stiffeners of bulkheads supporting hatch side girders or hatch end beams are to be bracketed at their ends.

5 Hatch supporting structures

5.1 General

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

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

5.1.2 Clear of openings, adequate continuity of strength of longitudinal hatch coamings is to be ensured by underdeck girders.

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

6 Openings in the strength deck

6.1 Position of openings and local strengthening

6.1.1 Openings in the strength deck are to be kept to a minimum and spaced as far apart from one another and from breaks of effective superstructures as practicable. Openings are generally to be cut outside the hatched areas; in particular, they are to be cut as far as practicable from hatchway corners.

The dashed areas in Fig 1 are those where openings are generally to be avoided. The meaning of the symbols in Fig 1 is as follows:

c, e : Longitudinal and transverse dimensions of hatched area:

$c = 0{,}07\ \ell + 0{,}10\ b$ without being less than 0,25 b,

$e = 0{,}25\ (B - b)$

a : Transverse dimension of openings

g : Transverse dimension of the area where openings are generally to be avoided in way of the connection between deck and side (as shown in Fig 1), deck and longitudinal bulkheads, deck and large deck girders:

- in the case of circular openings:

  $g = 2\ a$

- in the case of elliptical openings:

  $g = a$

6.1.2 No compensation is required where the openings are:

- circular of less than 350 mm in diameter and at a distance from any other opening in compliance with Fig 2
- elliptical with the major axis in the longitudinal direction and the ratio of the major to minor axis not less than 2.

Figure 1 : Position of openings in the strength deck

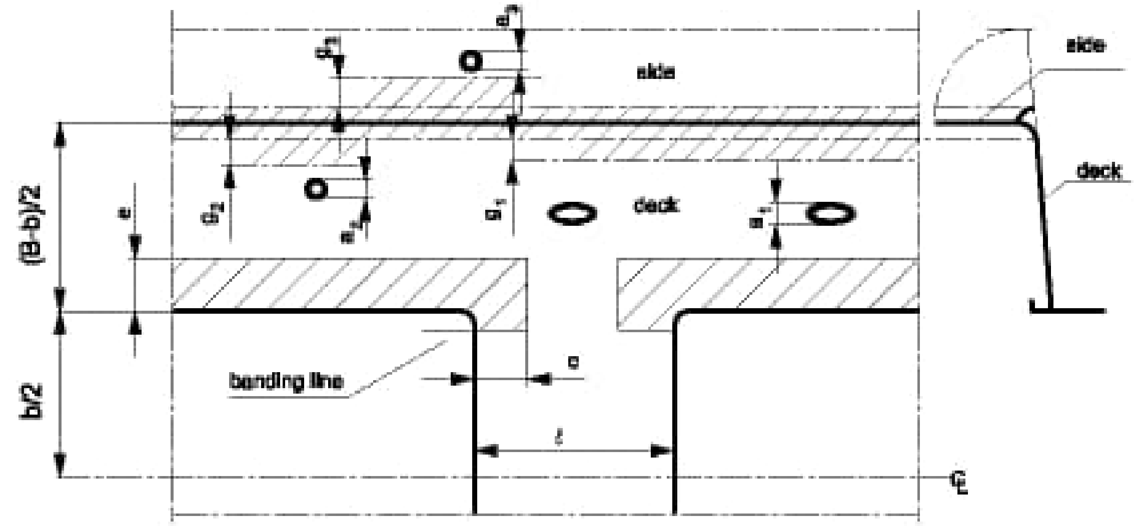
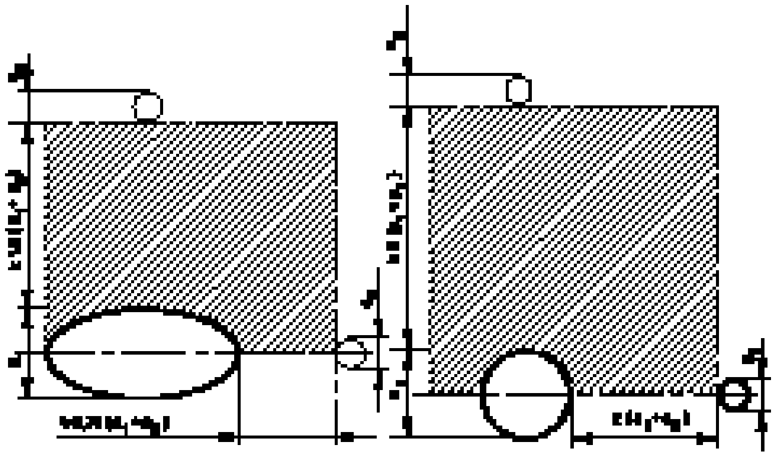


Figure 2 : Circular openings in the strength deck



6.2 Corners of hatchways

6.2.1 For hatchways located within the cargo area, insert plates, whose thickness is to be determined according to [6.2.3], are generally to be fitted in way of corners where the plating cut-out has a circular profile.

The radius of circular corners is to be not less than:

- 5% of the hatch width, where a continuous longitudinal deck girder is fitted below the hatch coaming
- 8% of the hatch width, where no continuous longitudinal deck girder is fitted below the hatch coaming.

Corner radiusing, in the case of the arrangement of two or more hatchways athwartship, is considered by the Society on a case by case basis.

6.2.2 For hatchways located in the positions specified in [6.2.1], insert plates are, in general, not required in way of corners where the plating cut-out has an elliptical or parabolic profile and the half axes of elliptical openings, or the half lengths of the parabolic arch, are not less than:

- 1/20 of the hatchway width or 600 mm, whichever is the lesser, in the transverse direction
- twice the transverse dimension, in the fore and aft direction.

6.2.3 Where insert plates are required, their thickness is obtained, in mm, from the following formula:

$$t_{INS} = \left(0{,}8 + 0{,}4\frac{\ell}{b}\right)t$$

without being taken less than t or greater than 1,6t

where:

ℓ : Width, in m, in way of the corner considered, of the cross deck strip between two consecutive hatchways, measured in the longitudinal direction (see Fig 1)

b : Width, in m, of the hatchway considered, measured in the transverse direction (see Fig 1)

t : Actual thickness, in mm, of the deck at the side of the hatchways.

For the extreme corners of end hatchways, the thickness of insert plates is to be 60% greater than the actual thickness of the adjacent deck plating. A lower thickness may be accepted by the Society on the basis of calculations showing that stresses at hatch corners are lower than pemissible values.

6.2.4 Where insert plates are required, the arrangement shown in Sheet 10.1 of Ch 12, App 1 is to be complied with.

6.2.5 For hatchways located in positions other than those in [6.2.1], a reduction in the thickness of the insert plates in way of corners may be considered by the Society on a case by case basis.

7 Openings in decks other than the strength deck

7.1 General

7.1.1 The requirements for such openings are similar to those in [6.1] for the strength deck. However, circular openings need not to be compensated.

7.1.2 Corners of hatchway openings are to be rounded, as specified in [6.2] for the strength deck; insert plates may be omitted, however, when deemed acceptable by the Society.

SECTION 7 BULKHEAD STRUCTURE

1 General

1.1 Application

1.1.1 The requirements of this Section apply to longitudinal or transverse bulkhead structures which may be plane or corrugated.

1.1.2 Bulkheads may be horizontally or vertically stiffened.

Horizontally framed bulkheads consist of horizontal ordinary stiffeners supported by vertical primary supporting members.

Vertically framed bulkheads consist of vertical ordinary stiffeners which may be supported by horizontal girders.

1.2 General arrangement

1.2.1 The number and location of watertight bulkheads are to be in accordance with the relevant requirements given in Ch 2, Sec 1.

1.2.2 For ships greater than 180 m in length, longitudinal corrugated bulkheads are to have horizontal corrugations and the upper and lower strakes of longitudinal corrugated bulkheads are to be plane up to a distance of at least 0,1D from deck and bottom.

Transverse corrugated bulkheads having horizontal corrugations are to be fitted with vertical primary supporting members of number and size sufficient to ensure the required vertical stiffness of the bulkhead.

1.2.3 Where an inner bottom terminates on a bulkhead, the lowest strake of the bulkhead forming the watertight floor of the double bottom is to extend at least 300 mm above the inner bottom.

1.2.4 Longitudinal bulkheads are to terminate at transverse bulkheads and are to be effectively tapered to the adjoining structure at the ends and adequately extended in the machinery space, where applicable.

1.2.5 Where the longitudinal watertight bulkheads contribute to longitudinal strength, the plating thickness is to be uniform for a distance of at least 0,1D from the deck and bottom.

1.2.6 The structural continuity of the bulkhead vertical and horizontal primary supporting members with the surrounding supporting structures is to be carefully ensured.

1.2.7 The height of vertical primary supporting members of longitudinal bulkheads may be gradually tapered from bottom to deck. The maximum acceptable taper, however, is 8 cm per metre.

1.3 Watertight bulkheads of trunks, tunnels, etc.

1.3.1 *Watertight trunks, tunnels, duct keels and ventilators are to be of the same strength as watertight bulkheads at corresponding levels. The means used for making them watertight, and the arrangements adopted for closing openings in them, are to be to the satisfaction of the Society.*

1.4 Openings in watertight bulkheads

1.4.1 Openings may not be cut in the collision bulkhead below the freeboard deck.

The number of openings in the collision bulkhead above the freeboard deck is to be kept to the minimum compatible with the design and proper working of the ship.

All such openings are to be fitted with means of closing to weathertight standards.

1.4.2 Certain openings below the freeboard deck are permitted in the other bulkheads, but these are to be kept to a minimum compatible with the design and proper working of the ship and to be provided with watertight doors having strength such as to withstand the head of water to which they may be subjected.

1.5 Watertight doors

1.5.1 The net thickness of watertight doors is to be not less than that of the adjacent bulkhead plating, taking account of their actual spacing.

1.5.2 Where vertical stiffeners are cut in way of watertight doors, reinforced stiffeners are to be fitted on each side of the door and suitably overlapped; cross-bars are to be provided to support the interrupted stiffeners.

1.5.3 Watertight doors required to be open at sea are to be of the sliding type and capable of being operated both at the door itself, on both sides, and from an accessible position above the bulkhead deck.

Means are to be provided at the latter position to indicate whether the door is open or closed, as well as arrows indicating the direction in which the operating gear is to be operated.

1.5.4 Watertight doors may be of the hinged type if they are always intended to be closed during navigation.

Such doors are to be framed and capable of being secured watertight by handle-operated wedges which are suitably spaced and operable at both sides.

2 Plane bulkheads

2.1 General

2.1.1 Where a bulkhead does not extend up to the uppermost continuous deck (such as the after peak bulkhead), suitable strengthening is to be provided in the extension of the bulkhead.

2.1.2 Bulkheads are to be stiffened in way of deck girders.

2.1.3 The stiffener webs of hopper and topside tank watertight bulkheads are generally to be aligned with the webs of inner hull longitudinal stiffeners.

2.1.4 Plate floors are to be fitted in the double bottom in way of plane transverse bulkheads.

2.1.5 A doubling plate of the same net thickness as the bulkhead plating is to be fitted on the after peak bulkhead in way of the sterntube, unless the net thickness of the bulkhead plating is increased by at least 60%.

2.2 End connections of ordinary stiffeners

2.2.1 In general, end connections of ordinary stiffeners are to be bracketed (see [2.3]). However, stiffeners of watertight bulkheads in upper 'tweendecks may be sniped, provided the scantlings of such stiffeners are modified accordingly.

2.2.2 Where hull lines do not enable compliance with the requirements of [2.2.1], sniped ends may be accepted, provided the scantlings of stiffeners are modified accordingly.

2.2.3 Where sniped ordinary stiffeners are fitted, the snipe angle is to be not greater than 30° and their ends are to be extended, as far as practicable, to the boundary of the bulkhead.

2.3 Bracketed ordinary stiffeners

2.3.1 Where bracketed ordinary stiffeners are fitted, the arm lengths of end brackets of ordinary stiffeners, as shown in Fig 1 and Fig 2, are to be not less than the following values, in mm:

- for arm length a:
  - brackets of horizontal stiffeners and bottom bracket of vertical stiffeners:

    $a = 100\ell$

  - upper bracket of vertical stiffeners:

    $a = 80\ell$

- for arm length b, the greater of:

$$b = 80\sqrt{\frac{w+20}{t}}$$

$$b = \alpha\frac{ps\ell}{t}$$

where:

ℓ : Span, in m, of the stiffener measured between supports

w : Net section modulus, in cm^3, of the stiffener

t : Net thickness, in mm, of the bracket

p : Design pressure, in kN/m^2, calculated at mid-span

α : Coefficient equal to:

$\alpha = 4,9$ for tank bulkheads

$\alpha = 3,6$ for watertight bulkheads.

Figure 1 : Bracket at upper end of ordinary stiffener on plane bulkhead

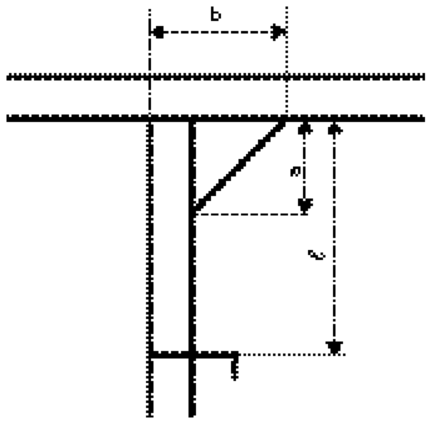
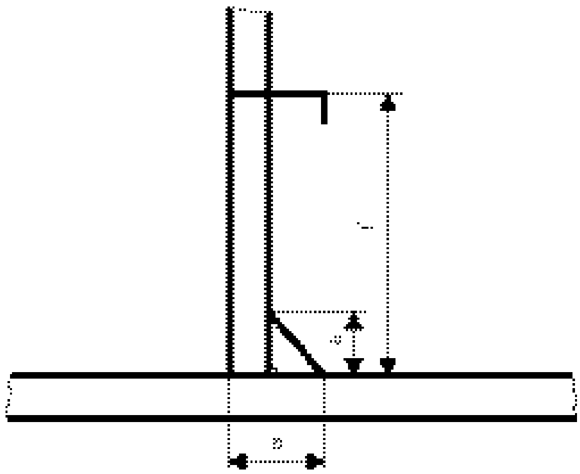


Figure 2 : Bracket at lower end of ordinary stiffener on plane bulkhead



2.3.2 The connection between the stiffener and the bracket is to be such that the net section modulus of the connection is not less than that of the stiffener.

3 Corrugated bulkheads

3.1 General

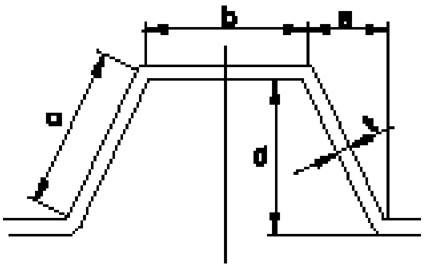
3.1.1 The main dimensions a, b, c and d of corrugated bulkheads are defined in Fig 3.

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

$a \leq 1,2d$

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

Figure 3 : Corrugated bulkhead



3.1.3 In general, the bending internal radius is to be not less than the following values, in mm:

- for normal strength steel:

  $R_i = 2,5\ t$

- for high tensile steel:

  $R_i = 3,0\ t$

where t is the net thickness, in mm, of the corrugated plate.

3.1.4 When butt 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.

Moreover, when the gross thickness of the bulkhead plating is greater than 20 mm, the Society may require the use of steel grade E or EH.

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

3.2 Structural arrangement

3.2.1 The strength continuity of corrugated bulkheads is to be ensured at ends of corrugations.

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

3.2.3 In general, where vertically corrugated transverse bulkheads are welded on the inner bottom, plate floors are to be fitted in way of the flanges of corrugations.

However, other arrangements ensuring adequate structural continuity may be accepted by the Society.

3.2.4 In general, where vertically corrugated longitudinal bulkheads are welded on the inner bottom, girders are to be fitted in way of the flanges of corrugations.

However, other arrangements ensuring adequate structural continuity may be accepted by the Society.

3.2.5 In general, the upper and lower parts of horizontally corrugated bulkheads are to be flat over a depth equal to 0,1D.

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

3.3 Bulkhead stool

3.3.1 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.

3.3.2 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.

3.3.3 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 net thickness and yield stress as those of the lower strake of the bulkhead.

4 Non-tight bulkheads

4.1 Non-tight bulkheads not acting as pillars

4.1.1 Non-tight bulkheads not acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- 0,9 m, for transverse bulkheads
- two frame spacings, with a maximum of 1,5 m, for longitudinal bulkheads.

4.2 Non-tight bulkheads acting as pillars

4.2.1 Non-tight bulkheads acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- two frame spacings, when the frame spacing does not exceed 0,75 m,
- one frame spacing, when the frame spacing is greater than 0,75 m.

4.2.2 Each vertical stiffener, in association with a width of plating equal to 35 times the plating net thickness, is to comply with the applicable requirements for pillars in Ch 7, Sec 3, the load supported being determined in accordance with the same requirements.

4.2.3 In the case of non-tight bulkheads supporting longitudinally framed decks, vertical girders are to be provided in way of deck transverses.

5 Wash bulkheads

5.1 General

5.1.1 The requirements in [5.2] apply to transverse and longitudinal wash bulkheads whose main purpose is to reduce the liquid motions in partly filled tanks.

5.2 Openings

5.2.1 The total area of openings in a transverse wash bulkhead is generally to be between 10% and 30% of the total bulkhead area.

In the upper, central and lower portions of the bulkhead (the depth of each portion being 1/3 of the bulkhead height), the areas of openings, expressed as percentages of the corresponding areas of these portions, are to be within the limits given in Tab 1.

5.2.2 In any case, the distribution of openings is to fulfil the strength requirements specified in [4.2].

5.2.3 In general, openings may not be cut within 0,15D from bottom and from deck.

Table 1 : Areas of openings in transverse wash bulkheads

Bulkhead portion	Lower limit	Upper limit
Upper	10 %	15 %
Central	10 %	50 %
Lower	2 %	10 %