Tasneef
هيئة الإمارات للتصنيف
Emirates Classification Society

Rules for the Classification of Naval Ships

Effective from 1 January 2025

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 authorized 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 shipbuilder, 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 shipowner, 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, for example, rule variations or interpretations.

"Services" means the activities described in paragraph 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, for example, offshore structures, floating units and underwater craft.

"Society" or "TASNEEF" means TASNEEF Maritime

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

"**Force Majeure**" means damage to the ship; unforeseen inability of the Society to attend the ship due to government restrictions on right of access or movement of personnel; unforeseeable delays in port or inability to discharge cargo due to unusually lengthy periods of severe weather, strikes or civil strife; acts of war; or other force majeure.

1. Society Roles

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

2. Rule Development, Implementation and Selection of Surveyor

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 also committed 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 based on 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 reinstatement. 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. 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 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.

3. Class Report & Interested Parties Obligation

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 the 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 part 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 authorized bodies and no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties based on 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 certification 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 seaworthiness, structural integrity, quality or fitness for a particular purpose or service of any Ship, structure, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society about its activities reflects the condition of the Ship or the subject of certification 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, shipbuilders, 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, the 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 about 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 concerning the services rendered by the Society are described in the Rules applicable to the specific service rendered.

4. Service Request & Contract Management

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.

4.3 The contractor for the classification of a ship or for the services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30/60/90 days' notice, to be given in writing. Failure to pay, even in part, the fees due for services carried out by the society will entitled the society to immediately terminate the contract and suspend the service.
For every termination of the contract, the fees for the activities performed until the time of the termination shall be owned 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 statutory certificates issued by society will be withdrawn in those cases where provided for by agreements between the society and the flag state.

5. Service Accuracy

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 **Rule Development, Implementation and Selection of Surveyor** 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.

6. Confidentiality & Document sharing

6.1. 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 authorization 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 class, 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.

6.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 below, the Society's clients 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 property 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.
6.3. 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, certificates, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty to ensure that, whenever required, the consent of the builder is obtained about the provision of plans and drawings to the new Society, either by way of the 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.

7. Health, Safety & Environment

7.1. The clients such as the designers, shipbuilders, manufacturers, repairers, suppliers, contractors or sub-contractors, or other product or system surveyed who have a registered office in ABU Dhabi; should have an approved OSHAD as per Abu Dhabi OHS Centre, or, if they do not need to have an approved OSHAD, they shall comply with TASNEEF standards and have procedures in place to manage the risks from their undertakings.

7.2. For the survey, audit and inspection activities onboard the ship, the ship's owner, the owner representative or the shipyard must follow TASNEEF rules regarding the safety aspects.

8. Validity of General Conditions

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

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9. Force Majeure

9.1 Neither Party shall be responsible to the other party for any delay or failure to carry out their respective obligations insofar as such delay and failure derives, directly or indirectly, and at any time, from force majeure of any type whatsoever that lies outside the control of either Party.

9.2 The Party that is unable to fulfil the agreement due to Force Majeure shall inform the other party without delay and in all cases within 7 days from when such force majeure arose.

9.3 It is understood that if such force majeure continues for more than 30 days, the Party not affected by the event may terminate this agreement by registered letter. The rights matured until the day in which the force majeure occurred remain unaffected.

10. Governing Law and Jurisdiction

This Agreement shall be governed by and construed in accordance with the laws of Abu Dhabi and the applicable Federal Laws of the UAE.
Any dispute arising out of or in accordance with this Agreement shall be subject to the exclusive jurisdiction of the Abu Dhabi courts.

11. Code of Business conduct

The **CLIENT** declares to be aware of the laws in force about the responsibility of the legal persons for crimes committed in their interest or to their own advantage by persons who act on their behalf or cooperate with them, such as directors, employees or agents.
In this respect, the **CLIENT** declares to have read and fully understood the "**Ethical Code**" published by **TASNEEF** and available in the **TASNEEF** Web site.
The **CLIENT**, in the relationships with **TASNEEF**, guarantees to refrain from any behaviour that may incur risk of entry in legal proceedings for crimes or offences, whose commission may lead to the enforcement of the laws above.
The **CLIENT** also acknowledges, in case of non-fulfilment of the previous, the right of **TASNEEF** to unilaterally withdraw from the contract/agreement even if there would be a work in progress situation or too early terminate the contract/agreement. It's up to **TASNEEF** to choose between the two above mentioned alternatives, and in both cases a registered letter will be sent with a brief sum-up of the circumstances or of the legal procedures proving the failure in following the requirements of the above-mentioned legislation.

In light of the above, it is forbidden to all employees and co-operators to:
- receive any commission, percentage or benefits of any possible kind;
- Start and maintaining any business relationship with **Clients** that could cause conflict of interests with their task and function covered on behalf of **TASNEEF.**
- Receive gifts, travel tickets or any other kind of benefits different from monetary compensation, that could exceed the ordinary business politeness.

Violation of the above-mentioned principles allows **TASNEEF** to early terminate the contract and to be entitled to claim compensation for losses if any.

EXPLANATORY NOTE TO PART B

1. Reference edition

The reference edition for Part B is the TasneefMIL 2003 edition, which is effective from 1st January 2003.

2. Effective date of the requirements

2.1 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 last updating. The effective date of all those requirements not followed by any date shown in brackets is that of the reference edition.

2.2 Item 5 below provides a summary of the technical changes from the preceding edition.

3. 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.

4. Rule subdivision and cross-references

4.1 Rule subdivision

The Rules are subdivided into five parts, from A to E.

Part A: Classification and Surveys

Part B: Hull and Stability

Part C: Machinery, Systems and Fire Protection

Part D: Service Notations

Part E: 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.

4.2 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.

5. Summary of amendments introduced in the edition effective from 1st January 2025

This edition of the Rules for the Classification of Naval Ships contains amendments whose effective date is **1 January 2025**.

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

FOREWORD

This is the 2025 edition of the “Rules for the classification of naval ships” (TasneefMIL), developed ad hoc taking into account the characteristics and features of naval surface ships.

RULES FOR THE CLASSIFICATION OF NAVAL SHIPS

Part B
Hull and Stability

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Part B
Hull and Stability

Chapter 1
GENERAL

SECTION 1 APPLICATION

1 General

1.1 Structural requirements

1.1.1 Part B of the Rules contains the requirements for determination of the minimum hull scantlings, applicable to all types of seagoing single hull displacement ships of normal form, speed and proportions, made in welded steel construction. These requirements are to be integrated with those specified in Part D, for any individual ship type, and in Part E, as applicable, depending on the additional class notations assigned to the ships.

1.1.2 The requirements of Part B, Part D and Part E 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 *(1/1/2025)*

The strength of ships constructed and maintained according to the Rules is sufficient for the draught corresponding to the scantling draught. The scantling draught considered when applying the Rules is to be not less than that corresponding to the assigned intact ship deepest full load waterline.

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 and weapons

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 weapons and their connections to the ship's structure are covered by the Rules.

1.2.3 As far as the weapons are concerned, the load effects of blast and recoil on the structures are covered by the Rules. The safety aspects regarding personnel and other systems are not covered by the Rules.

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 general arrangement and 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 general arrangement and scantling of other ship items according to Tab 2.

Table 1 : Part B Rules requirements applicable for the general arrangement and scantling of ship parts

Part	Applicable Chapters and Sections	
	General	Specific
Fore part	Chapter 1 Chapter 2 Chapter 3 Chapter 4 Chapter 8 **(1)**, excluding: • Ch 8, Sec 1 • Ch 8, Sec 2 Chapter 10 Chapter 11	Ch 8, Sec 1
Central part		Chapter 5 Chapter 6 Chapter 7
Aft part		Ch 8, Sec 2
(1) See also [2.3].		

Table 2 : Part B Rules requirements applicable for the general arrangement and scantling of other items

Item	Applicable Chapter and Section
Machinary space	Ch 8, Sec 3
Superstructures and deckhouses	Ch 8, Sec 4
Bow doors and Inner doors	Ch 8, Sec 5
Slide shell doors and stern doors	Ch 8, Sec 6
Hatch covers	Ch 8, Sec 7
Movable decks and inner ramp External ramps	Ch 8, Sec 8
Rudders	Ch 9, Sec 1
Hull oufitting and masts	Ch 9, Sec 2 Ch 9, Sec 3 Ch 9, Sec 4 Ch 9, Sec 5

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%.

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.

Table 1 : Units

Designation	Usual symbol	Units
Ship's dimensions	See [2]	m
Hull girder section modules	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
Thickness	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 modules of ordinary stiffeners and primary supporting members	w	cm^3
Sectional area of ordinary stiffeners and primary supporting members	A	cm^2

2 Definitions

2.1 Symbols

2.1.1 *(1/1/2025)*

L_{BP} : Length between perpendiculars, in m, defined in [4.1]

L : Rule length, in m, defined in [4.3]

L_{LL} : Load line length, in m, defined in [4.4]

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

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

B : Moulded breadth, in m, defined in [4.5]

D : Depth, in m, defined in [4.6]

D_1 : Least moulded depth, in m, defined in [4.7]

T : Scantling draught, in m, defined in [4.8]

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

C_B : Total block coefficient

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

3 Waterlines

3.1 General

3.1.1 Subdivision load line

Subdivision load line is a waterline used in determining the subdivision of the ship.

3.1.2 Deepest subdivision load line

Deepest subdivision load line is the waterline which corresponds to the greatest draught permitted by the subdivision requirements which are applicable.

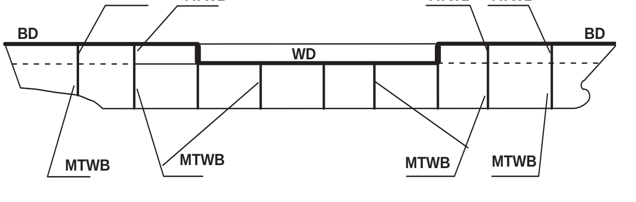
3.2 Subdivision lines

3.2.1 Margin line (1/7/2011)

Margin line is a line drawn at least 76 mm below the upper surface of the bulkhead deck at side.

If the bulkhead deck is stepped along the ship's length, the margin line may be stepped accordingly.

Figure 1 : Typical watertight subdivision in front line and second line ships



3.2.2 Submergible areas *(1/7/2011)*

Some areas of the vessel as mooring and quartering areas, may result immersed in damage condition provided that every access or openings to the adjacent compartments are watertight, so that progressive flooding is avoided. In respect of structural scantling, the bounding bulkheads have to be considered as the hull.

To the purpose of considering an area submergible it have to be complying the following requirements:

- all the openings have to be closed by watertight closure such to face the hydrostatic head corresponding to the maximum draft.
- not compromise, when immersed, the access to area essential for surviving.

3.2.3 ”V” Lines *(1/7/2011)*

At each ship section, "V" Lines identifies at an early stage of design whereas the auxiliary watertight bulkheads may be crossed without particular requirements relevant to the restoring of watertight integrity taking into account the envelope of the waterlines at the end of each symmetrical flooding for all loading conditions and given heeling and immersion margin (see Ch 3, App 4).

4 Dimensions

4.1 Length between perpendiculars

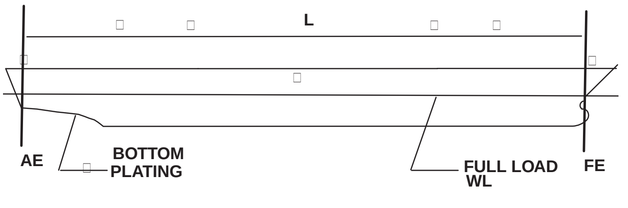
4.1.1 *(1/1/2017)*

The length between perpendiculars L_{BP}, see Fig 2, is the distance, in m, measured on the deepest full load waterline between the aft end (AE) and the fore end (FE), as defined in [4.2].

4.1.2 *(1/1/2017)*

In ships with unusual stem or stern arrangements, the length between perpendiculars L_{BP} is considered on a case by case basis.

Figure 2 : Length between perpendiculars L_{BP}



4.2 Ends of length between perpendiculars L_{BP} and midship

4.2.1 Aft end *(1/1/2017)*

The aft end (AE) of the length between perpendiculars L_{BP} is the perpendicular to the deepest full load waterline at the lowest corner between the transom and the bottom plating.

4.2.2 Fore end *(1/1/2017)*

The fore end (FE) of the length between perpendiculars L_{BP}, is the perpendicular to the deepest full load waterline at the forward side of the stem.

4.2.3 Midship

The midship is the perpendicular to the deepest full load waterline at a distance $0,5L_{BP}$ aft of the fore end FE.

4.3 Rule Length

4.3.1 *(1/1/2025)*

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.

4.3.2 *(1/1/2025)*

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.

4.3.3 *(1/1/2017)*

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

4.4 Load Line Length

4.4.1 *(1/1/2017)*

The load line length L_{LL} is the distance, in m, on the waterline at 85% of the least moulded depth D_1 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.

4.4.2 *(1/1/2017)*

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).

4.4.3 *(1/1/2017)*

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

4.5 Moulded breadth

4.5.1 *(1/1/2025)*

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

4.6 Depth

4.6.1 The operational 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 at side on the uppermost continuos 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.

4.7 Least Moulded Depth

4.7.1 *(1/1/2017)*

The least moulded depth D1 is the least vertical distance, in m, measured from the top of the keel to the top of the bulkhead 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 bulkhead 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.

4.8 Scantling draught

4.8.1 *(1/1/2025)*

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.

4.8.2 In the case of ships with a solid bar keel, the moulded base line is to be taken as defined in [4.6.1].

5 Ship weights

5.1 Lightship

5.1.1 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 lubricant and hydraulic, which are at operating levels.

5.2 Full load

5.2.1 The full load condition corresponds to the ship loaded departure as defined in Tab 2.

5.3 Operational load

5.3.1 The operational load condition corresponds to the ship for replenishment as defined in Tab 2.

5.4 Minimum operational load

5.4.1 The minimum operational load corresponds to the ship for replenishment as defined in Tab 2.

5.5 Deadweight

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

6 Decks and bulkheads

6.1 General

6.1.1 From the point of view of subdivision and stability of surface vessels it is to define two kind of tightness:

- watertight
- weathertight

6.1.2 Watertight

The watertight elements assure the tightness even with a constant hydrostatic head.

6.1.3 Weathertight

The weathertight elements assure the tightness under the action of weather agents, hose or temporary phase during rolling periods.

Table 2 : Definition of loading cases (% of mass or specified maximum loads) *(1/1/2017)*

Components	Full load	Operatinal condition	Minimum operational condition	Comments
Lightship	100%	100%	100%	See [5.1.1]
Crew with luggage	100%	100%	100%	
External personnel with equipment	100%	100%	100%	Personnel not belonging to the crew
Ship logistic material	100%	100%	100%	On board documents, equipments for repairs
Foods	100%	66,6%	33,3%	Uniformly distributed in storage spaces, unless otherwise specified
Ammunitions	100%	66,6%	33,3%	In storage spaces above the ship centre of gravity
Ammunitions	100%	100%	100%	In storage spaces below the ship centre of gravity in all preparing spaces(above and below ship CoG)
Helicopters with their logistic	100%	100%	100%	At location as specified
Cargo with their logistic	100%	100%	0%	At location as specified

Components	Full load	Operatinal condition	Minimum operational condition	Comments
Fuels (propulsion, auxiliaries, helicopters,...)	100%	66,6%	33,3%	Uniformly distributed in capacities, unless otherwise specified
Fuels (propulsion, auxiliaries, helicopters,...)	100%	100%	100%	For service tank with an automatic continuos compensation system
Lubricant storage	100%	66,6%	33,3%	Uniformly distributed in capacities
Other consumable materials	100%	66,6%	33,3%	Otherwise specified uniformly distributed in storage spaces
Drinking water	100%	66,6%	66,6%	When produced on board, uniformly distributed in capacities
Drinking water	100%	66,6%	33,3%	When not produced on board, uniformly distributed in capacities
Industrial waters	100%	66,6%	66,6%	
Grey and black waters	0%	33,3%	33,3%	
Ballast waters	0%	0%	0%	Unless otherwise specified
Stabilising tanks	op. level	op. level	op. level	At the operational level
Non consumables and pumping residues	100%	100%	100%	
Miscellaneous	100%	100%	100%	Mobile liquid or solid ballast, building mass margin (see Ch 3, Sec 2)

6.2 Bulkhead Deck (B.D.)

6.2.1 *(1/7/2011)*

The Bulkhead Deck is the highest deck to which auxiliary watertight transversal bulkheads are raised.

The Bulkhead Deck may be stepped along the ship's length.

6.3 Main deck (M.D.)

6.3.1 *(1/1/2025)*

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

Unless otherwise specified in the Regulatory Framework and subject to the approval of the Society, a lower deck may be designated as the main deck provided it is a complete and permanent deck continuous in a fore and aft direction and continuous athwartships.

6.4 Watertight deck (W.D.)

6.4.1 *(1/1/2025)*

Unless otherwise specified in the Regulatory Framework, in **front line** and **second line** ships watertight bulkheads are to be vertically limited by a watertight deck.

The watertight deck is the first watertight deck which constitutes the vertical limit (See Fig 3, function 2) or transversal limit (function 3) of the flooding of the ship caused by a damage interesting the shell of the ship below the waterline. Samely it may be the first watertight deck which bounds the longitudinal flooding (Fig 3, function 1) of the ship after damage caused by fighting (the breach involves all the height of the ship) when not all Main Transversal Watertight bulkheads (M.T.W.B.) are extended up to the Bulkhead Deck. It is the deck below which all the openings in the shell and the crossing through the main transversal bulkheads are forbidden (or guided according the requirements of Ch 2, Sec 1, Tab 3 "Requirements for openings and Crossing in several water(weather)tight elements").

It has to be supplied with watertight closures such to restore its integrity.

Generally it assumes the function of "Damage Control deck".

6.5 Damage Control deck

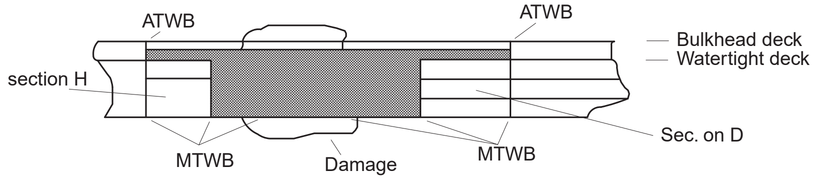
6.5.1 The damage control deck is the deck above which all the devices of the safety systems and damage control are installed. It allows movements in a fore and aft, and vice versa, direction.

6.6 Main transversal watertight bulkhead (M.T.W.B.)

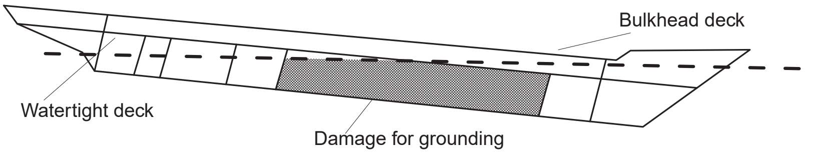
6.6.1 *(1/7/2011)*

In ships fitted with watertight deck, the main transversal watertight bulkheads are the part of watertight bulkheads below the watertight deck. See Fig 1.

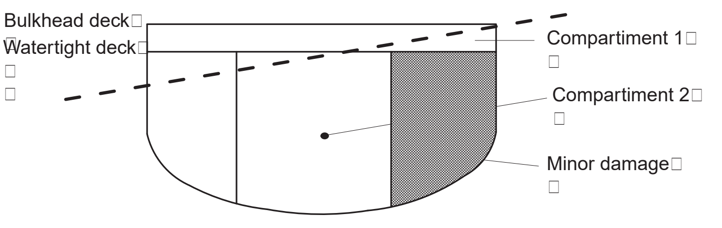
Figure 3 : Function of watertight deck



Function 1 : the damage is conventional, the watertight deck avoid the flooding of the section is H and D below this deck



Function 2 : the damage has longitudinal extension longer than the conventional damage, but a limited height, the watertight deck avoid the progressive flooding of the sections A and B



Function 3 : the damage is extended less than the conventional damage, the watertight deck avoid the flooding of the compartments 1 and 2, so timing the major effects of the damage

6.7 Main Watertight Compartment

6.7.1 *(1/7/2011)*

A main watertight compartment is a volume bounded by two main transversal watertight bulkheads.

It has to be distinguished from the safety zone of fire protection.

The minimum distance between M.T.W.B., therefore minimum length of a compartment, is provided by the formulas:

- 3 m + 3% L_{pp}, for ships with L_{pp} less than 250 m.
- 10,5 m for ships with length L_{pp} not less than 250 m.

6.8 Auxiliary transversal watertight bulkheads (A.T.W.B.)

6.8.1 *(1/7/2011)*

In ships fitted with watertight deck, the main transversal watertight bulkheads are the part of watertight bulkheads between the watertight deck and the bulkhead deck. See Fig 1.

7 Spaces definition

7.1 Machinery space

7.1.1 Machinery space is to be taken as extending from the moulded base line to the margin line and between the extreme main transverse watertight bulkheads, bounding the spaces containing the main and auxiliary propulsion machinery, boilers serving the needs of propulsion, and all permanent coal bunkers.

7.2 Machinery spaces of category A

7.2.1 Machinery spaces of category A are those spaces or trunk 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.

7.3 Ro-ro cargo spaces

7.3.1 Ro-ro cargo spaces are spaces not normally subdivided in any way and extending to either a substantial length or the entire length of the ship in which goods (packaged or in bulk, or in land vehicles, or in barges or crafts) can be loaded and unloaded normally in a horizontal direction.

7.4 Accommodation spaces

7.4.1 Personnel *(1/7/2011)*

Personnel include all crew, personnels needed to operate equipments and weapons, embarked officers and soldiers for particular operations.

7.4.2 Accommodation spaces *(1/7/2011)*

Accommodation spaces are those spaces which are provided for the accommodation and use of personnel, excluding baggage, store, provisions and mail rooms.

In all cases volumes and areas are to be calculated to moulded lines.

7.5 Special category spaces

7.5.1 Special category spaces are those enclosed spaces above or below the subdivision deck intended for the carriage of motor vehicles, or barges or crafts, with fuel in their tanks for their own propulsion, into and from which such vehicles can be driven and to which passengers have access.

7.6 Military special category spaces

7.6.1 Military special category spaces are special category spaces intended for the carriage of motor vehicles, or barges or crafts with ammunitions.

8 Superstructures

8.1 General

8.1.1 *(1/1/2017)*

A superstructure is a decked structure connected to the bulkhead 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.

8.2 Enclosed and open supestructure

8.2.1 A superstructure may be enclosed, where:

- it is enclosed by front side and aft bulkheads complying with the requirements of Ch 8, Sec 4.
- all front, side and aft openings are fitted with efficient weathertight means of closure

open, where it is not enclosed.

8.3 Raised quarterdeck

8.3.1 A raised quarterdeck is a partial superstructure of reduced height.

8.4 Deckouse

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

8.5 Trunk

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

9 Deck positions

9.1 Definitions

9.1.1 Position 1

Position 1 includes:

- exposed main deck and raised quarter decks,
- exposed superstructure decks situated forward of 0,25 L_{LL} from the fore end FE.

9.1.2 Position 2

Position 2 includes exposed superstructure decks situated aft of 0,25 L from the fore end FE.

10 Reference co-ordinate system

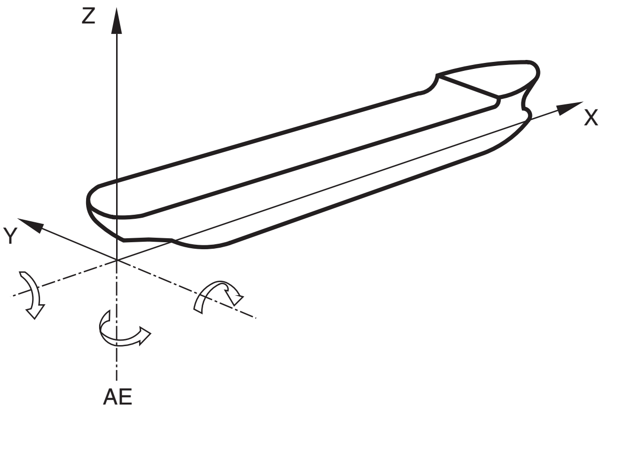
10.1

10.1.1 The ship’s geometry, motions, accelerations and loads are defined with respect to the following right-hand co-ordinate system (see Fig 4):

- 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.

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

Figure 4 : 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.

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 11, Sec 1, [1.5].

1.1.2 Plans and documents to be submitted for information

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 9, Sec 4, [3.1].

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.

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

2.1 General

2.1.1 Depending on 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] for the additional class notations which require this additional documentation.

2.2 Additional class notations

2.2.1 The plans or documents to be submitted to the Society are listed in Tab 1.

Table 1 : Plans and documents to be submitted for approval for all ships *(1/1/2025)*

Plan or document	Containing also information on
Watertight subdivision decks Watertight subdivision bulkheads Watertight tunnels	Openings and their closing appliances, if any
Plan of watertight doors and scheme of relevant manoeuvring devices	Manoeuvring devices Electrical diagrams of power control and position indication circuits
Loading manual and loading instruments	See Ch 10, Sec 2, [3]
Calculations relevant to intact stability and damage stability	See Ch 3, Sec 3
Stability documentation	See Ch 3, Sec 1, [3.1]
(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 9, Sec 1, [11]. **(2)** 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
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
Fore 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
Aft part structure	Location and height of air vent outlets of various compartments
Sternframe or sternpost, sterntube Propeller shaft boss and brackets **(1)**	
Rudder and rudder horn **(1)**	Maximum ahead service speed
Transverse thruster, if any, general arrangement, tunnel structure, connections of thruster with tunnel and hull structures	
Superstructures and deckhouses Machinery space casing	Extension and mechanical properties of the aluminium alloy used (where applicable)
Helicopter landing decks	General arrangement Main structure Characteristics of helicoters: maximum mass , distance between axles of wheels or skids, print area of wheels or skids, rotor diameter.
Plan of ventilation	Use of spaces
Scuppers and sanitary discharges	
Bulwarks and freeing ports	Arrangement and dimensions of bulwarks and freeing ports on the exposed deck
Hawse pipes	
Windows and side scuttles, arrangements and details	
Sea chests, stabiliser recesses, etc.	
Plan of manholes	
Plan of access to and escape from spaces	
Plan of outer doors and hatchways	
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

(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 9, Sec 1, [11].

(2) 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
Movable decks and ramps, if any	
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
Derricks and cargo gear Cargo lift structures	Design loads (forces and moments) including weapon loads Connections to the hull structures
Plan of tank testing	Testing procedures for the various compartments Height of pipes for testing
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
Scantling of structures subjected to weapon firing loads	Normal mode analysis and, when necessary, dynamic analysis
Dynamic analysis of the hull girder	Normal mode analysis and, when necessary, dynamic analysis
Structural analysis for masts	Normal mode analysis and, when necessary, dynamic analysis
Windlass	Design loads, scantlings and connections to the hull structures
Towing and mooring arrangements	Design loads, scantlings and connections to the hull structures
Ventilator pipes within forward quarter length of the ship **(2)**	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 9, Sec 1, [11]. **(2)** 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.	

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 The LEONARDO HULL program performs the rule scantling check of plating and ordinary stiffeners at any transverse section along the ship's hull.

1.2.2 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.

1.2.3 LEONARDO HULL also calculates the steel renewal thicknesses based on rule scantlings and permits the reassessment of ships in service.

Transverse section scantling verification and finite element analysis of hull structure, including automatic generation of part of the finite element model, are integrated in one software package. Additionally there is automatic load calculation, model load case generation, and scantling criteria verification, in accordance with the Rules.

Part B
Hull and Stability

Chapter 2
GENERAL ARRANGEMENT DESIGN

Symbols used in chapter 2

FP : "forward perpendicular". The forward perpendicular is to be taken at the forward end of the length L and is to coincide with the foreside of the stem on the waterline on which the length L is measured.

AP : "after perpendicular". The after perpendicular is to be taken at the after end of the length L.

SECTION 1 SUBDIVISION ARRANGEMENT

1 General

1.1 Definitions

1.1.1 Ship dimensions

The ship dimensions are defined in Ch 1, Sec 2, [4].

1.1.2 Watertight decks and bulkheads

The definitions of the watertight decks and bulkheads are given in Ch 1, Sec 2.

2 Number and arrangement of transverse watertight bulkheads

2.1 Number of watertight bulkheads

2.1.1 General

All ships, in addition to complying with the requirements of [2.1.2], are to have at least the following main 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.

2.1.2 Additional bulkheads

Main transverse watertight bulkheads are to be fitted adequately spaced to comply with stability criteria (see Ch 3, Sec 3)

As a guidance, the minimum number of main transverse watertigh bulkheads versus ship lengths can be estimated from Tab 1.

Table 1 : Minimum number of bulkheads

Length, in m	Total numbers of bulkheads	
	Machinery amidships	Machinery aft - see **(1)**
L < 65	4	3
65 < L ? 85	4	4
85 < L ? 90	5	5
90 < L ? 105	5	5
105 < L ? 115	6	5
115 < L ? 125	6	6
125 < L ? 145	7	6
145 < L ? 165	8	7
165 < L ? 190	9	8
L > 190	to be considered individually	

(1) With after peak bulkhead forming after boundary of machinery space.

2.2 Number of subdivision bulkheads

2.2.1 Criteria

The number of subdivision bulkheads is defined with respect to the operational constraints and to fulfill the damage stability criteria (see Ch 3, Sec 3).

2.3 Bulkhead arrangement

2.3.1 Bulkheads effectiveness

To be effective, the distance between two adjacent main Watertight bulkheads cannot be lower than 3.0 m plus 3% of the length L of the ship or 11.0 m , whichever is the lesser.

2.3.2 Stepper bulkheads

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

3 Collision bulkhead

3.1 Arrangement of collision bulkhead

3.1.1 *(1/7/2011)*

A fore peak or collision bulkhead is to be fitted which is to be watertight up to the bulkhead deck. This bulkhead is to be located at a distance, in m, from the forward perpendicular of not less than 5% of the length L of the ship and not more than 3 m plus 5% of the length L of the ship.

3.1.2 Where any part of the ship below the waterline extends forward perpendicular, e.g. a bulbous bow, the distances, in metres, stipulated in [3.1.1] are to be measured from a point either:

- at the midlength of such extension, or
- at a distance 1,5 % of the length L of the ship forward of the forward perpendicular, or
- at a distance 3 m forward of the forward perpendicular; whichever gives the smallest measurement.

3.1.3 The bulkhead may have steps or recesses provided they are within the limits prescribed in [3.1.1] or [3.1.2].

No door, manhole, ventilation duct or any other opening is to be fitted in this bulkhead.

3.1.4 The Society may, on a case by case basis, accept a distance from the collision bulkhead to the forward perpendicular greater than the maximum specified in [3.1.1] and [3.1.2], provided that subdivision and stability calculations show that, when the ship is in upright condition on full load , flooding of the space forward of the collision bulkhead will not result in any part of the bulkhead deck becoming submerged, or in any unacceptable loss of stability.

3.1.5 Where a long forward superstructure is fitted, the collision bulkhead is to be extended weathertight to the next deck above the bulkhead deck. The extension need not be fitted directly above the bulkhead below provided it is located within the limits prescribed in [3.1.1] or [3.1.2] and the part of the deck which forms the step is made effectively weathertight.

4 After peak, machinery space bulkheads and stern tubes

4.1 General

4.1.1 An after peak bulkhead, and bulkheads dividing the machinery space from the cargo and personnel spaces forward and aft, are also to be fitted and made watertight up to the bulkhead deck. The after peak bulkhead may be stepped, provided the degree of safety of the ship as regards subdivision is not thereby diminished.

4.1.2 Sterntubes

In all cases sterntubes are to be enclosed in a watertight spaces of moderate volume.The stern gland is to be situated in a watertight shaft tunnel or other watertight space separate from the sterntube compartment and of such volue that, if flooded by leakage through the stern gland, the margin line is not submerged.

5 Openings in watertight bulkheads and decks

5.1 Definitions

5.1.1 *(1/7/2011)*

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 bulkhead deck, provided that it is demonstrated that any progressive flooding can be easily controlled and that the safety of the ship is not impaired.

5.1.2 *(1/7/2011)*

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

5.1.3 *(1/7/2011)*

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.

5.1.4 *(1/7/2011)*

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

5.1.5 *(1/7/2011)*

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 [5.2] and [5.3] are specified in Tab 2.

5.1.6 *(1/7/2011)*

For front line and second line ships the openings allowed in watertight/weathertight boundaries are indicated in Tab 3.

5.1.7 *(1/1/2025)*

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.

5.2 Openings in bulkheads above the bulkhead deck

5.2.1 General *(1/7/2011)*

Measures such as the fitting of partial bulkheads or diaphragms are to be taken to limit the entry and spread of water above the bulkhead deck. When partial watertight bulkheads and diaphragms are fitted on the bulkhead deck, above or in the immediate vicinity of main subdivision bulkheads, their connections with the shell and bulkhead deck are to be watertight so as to restrict the flow of water along the deck when the ship is in a heeled damaged condition. Where the partial watertight bulkhead does not line up with the bulkhead below, the bulkhead deck between is to be made effectively watertight.

The bulkhead deck or a deck above it is to be weathertight.

The coamings of all openings in the exposed weather deck are to be of ample height and strength and are to be provided with efficient means for expeditiously closing them weathertight. Freeing ports, open rails and scuppers are to be fitted as necessary for rapidly cleaning the weather deck of water under all weather conditions.

Sidescuttles, gangway ports and other means for closing openings in the shell plating above the margin line are to be of efficient design and construction and of sufficient strength (see Pt B, Ch 8, Sec 9) having regard to the spaces in which they are fitted and their positions relative to the deepest waterline.

Efficient inside deadlights, so arranged that they can be easily and effectively closed and secured watertight, are to be provided for all sidescuttles to spaces below the first deck above the bulkhead deck.

Table 2 : Doors *(1/7/2011)*

		Sliding type			Hinged type		
		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
Below bulkhead deck watertight doors	Open at sea **(1)**	X				X	
	Normally closed **(1) (2)**		X			X	
	Permanently closed **(2)**						X **(3) (4)**
Above bulkhead deck - weathertight / watertight **(5)**	Open at sea **(1)**					X	
	Normally closed **(2)**					X	
	Permanently closed **(2)**						X

(1) Sliding type doors are required when they are located below the waterline at the equilibrium of the final and intermediate stage of flooding; otherwise a hinged door is accepted. Normally closed doors in the watertight boundary of the garage area and leading in to small confined spaces where the presence of personnel is not frequent (e.g. stores, service spaces, workshops and similar), irrespectively of the waterline at the equilibrium of the final and intermediate stage of flooding, may be hinged type watertight door provided that such doors opens outward.
(2) Notice to be affixed on both sides of the door: "to be kept closed at sea".
(3) The door is to be closed before the voyage commences.
(4) If the door is accessible during the voyage, a device which prevents unauthorised opening is to be fitted.
(5) Watertight doors are required when they are located below the waterline at the equilibrium of the intermediate stages of flooding

6 Doors

6.1 Requirements for doors

6.1.1 *(1/7/2011)*
The requirements relevant to the degree of tightness, as well as the operating systems, for doors complying with the prescriptions in [6.2] are specified in Tab 2.

6.2 Watertight doors

6.2.1 Construction of watertight doors *(1/7/2011)*

The design, materials and construction of all watertight doors are to be to the satisfaction of the Society.

The frames of vertical watertight doors are to have no groove at the bottom in which dirt might lodge and prevent the door closing properly.

6.2.2 *(1/7/2011)*
Watertight doors are to be capable of being closed simultaneously from the central operating console at the navigation bridge and at the damage control station(s) in not more than 60 s with the ship in the upright position.

6.2.3 *(1/7/2011)*
The means of operation whether by power or by hand of any power-operated sliding watertight door are to be capable of closing the door with the ship listed to 15° either way. Consideration is also to be given to the forces which may act on either side of the door as may be experienced when water is flowing through the opening applying a static head equivalent to a water height of at least 1 m above the sill on the centreline of the door.

6.2.4 *(1/7/2011)*
Watertight door controls, including hydraulic piping and electrical cables, are to be kept as close as practicable to the bulkhead in which the doors are fitted, in order to minimise the likelihood of them being involved in any damage which the ship may sustain. The positioning of watertight doors and their controls are to be located, as far as possible, across the centre line of the ship.

6.2.5 *(1/7/2011)*
All power-operated sliding watertight doors are to be provided with means of indication which show at all remote operating positions whether the doors are open or closed. Remote operating positions are only to be located at the navigating bridge, at the damage control station(s) and at

the location where hand operation above the bulkhead deck is required by [6.2.6].

6.2.6 *(1/7/2011)*

Each power-operated sliding watertight door:

a) is to move vertically or horizontally;

b) is to be normally limited to a maximum clear opening width of 1,20 m. The Society may permit larger doors only to the extent considered necessary for the effective operation of the ship provided that other safety measures, including the following, are taken into consideration:
   - special consideration is to be given to the strength of the door and its closing appliances in order to prevent leakages;
   - the door is to be located across the centre line of the ship;
   - the door is to be kept closed when the ship is at sea, except for limited periods when absolutely necessary as determined by the Society.

c) is to be fitted with the necessary equipment to open and close the door using electrical power, hydraulic power, or any other form of power that is acceptable to the Society;

d) is to be provided with an individual hand-operated mechanism. It is to be possible to open and close the door by hand at the door itself from either side and, in addition, close the door from an accessible position above the bulkhead deck with an all round crank motion or some other movement providing the same degree of safety acceptable to the Society. Direction of rotation or other movement is to be clearly indicated at all operating positions. The time necessary for the complete closure of the door, when operating by hand gear, may not exceed 90 s with the ship in the upright position;

e) is to be provided with controls for opening and closing the door by power from both sides of the door and also for closing the door by power from the central operating console at the navigation bridge and at the damage control station(s);

f) is to be provided with an audible alarm, distinct from any other alarm in the area, which is to sound whenever the door is closed remotely by power and which is to sound for at least 5 s but no more than 10 s before the door begins to move and is to continue sounding until the door is completely closed. In the case of remote hand operation it is sufficient for the audible alarm to sound only when the door is moving. Additionally, in areas of high ambient noise, the Society may require the audible alarm to be supplemented by an intermittent visual signal at the door;

g) is to have an approximately uniform rate of closure under power. The closure time, from the time the door begins to move to the time it reaches the completely closed position, is to in no case be less than 20 s or more than 40 s with the ship in the upright position.

6.2.7 *(1/7/2011)*

The electrical power required for power-operated sliding watertight doors is to be supplied from the emergency source either directly or by a dedicated distribution board situated above the bulkhead deck.

The associated control, indication and alarm circuits are to be supplied from the emergency source either directly or by a dedicated distribution board situated above the bulkhead deck and be capable of being automatically supplied by a transitional source of emergency electrical power in the event of failure of either the main or emergency source of electrical power.

The transitional source of emergency electrical power is to consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be of sufficient capacity and so arranged as to supply power automatically, in the event of failure of either the main or emergency source of electrical power, to control, indication and alarm circuits at least for half an hour.

6.2.8 *(1/7/2011)*

Power-operated sliding watertight doors are to have either:

a) a centralised hydraulic system with two independent power sources each consisting of a motor and pump capable of simultaneously closing all doors. In addition, there are to be for the whole installation hydraulic accumulators of sufficient capacity to operate all the doors at least three times, i.e. closed-open-closed, against an adverse list of 15°. This operating cycle is to be capable of being carried out when the accumulator is at the pump cut-in pressure. The fluid used is to be chosen considering the temperatures liable to be encountered by the installation during its service. The power operating system is to be designed to minimise the possibility of having a single failure in the hydraulic piping adversely affect the operation of more than one door. The hydraulic system is to be provided with a low-level alarm for hydraulic fluid reservoirs serving the power-operated system and a low gas pressure group alarm or other effective means of monitoring loss of stored energy in hydraulic accumulators. These alarms are to be audible and visual and are to be situated on the central operating console at the navigating bridge and at the damage control station(s); or

b) an independent hydraulic system for each door with each power source consisting of a motor and pump capable of opening and closing the door. In addition, there is to be a hydraulic accumulator of sufficient capacity to operate the door at least three times, i.e. closed-open-closed, against an adverse list of 15°. This operating cycle is to be capable of being carried out when the accumulator is at the pump cut-in pressure. The fluid used is to be chosen considering the temperatures liable to be encountered by the installation during its service. A low gas pressure group alarm or other effective means of monitoring loss of stored energy in hydraulic accumulators is to be provided at the central operating console on the navigation bridge and at the damage control station(s). Loss of stored energy indication at each local operating position is to also be provided; or

c) an independent electrical system and motor for each door with each power source consisting of a motor capable of opening and closing the door.

The power source is to be capable of being automatically supplied by the transitional source of emergency electrical power in the event of failure of either the main or emergency source of electrical power and with sufficient capacity to operate the door at least three times, i.e. closed-open-closed, against an adverse list of 15°.

The transitional source of emergency electrical power is to consist of an accumulator battery suitably located for use in an emergency which is to operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage and be of sufficient capacity and so arranged as to supply power automatically, in the event of failure of either the main or emergency source of electrical power, to watertight doors, but not necessarily all of them simultaneously, unless an independent source of stored energy is provided.

For the systems specified above, power systems for power-operated watertight sliding doors are to be separate from any other power system. A single failure in the electrical or hydraulic power-operated systems excluding the hydraulic actuator may not prevent the hand operation of any door.

6.2.9 *(1/7/2011)*

Control handles are to be provided at each side of the bulkhead at a minimum height of 1,6 m above the floor and are to be so arranged as to enable persons passing through the doorway to hold both handles in the open position without being able to set the power closing mechanism in operation accidently. The direction of movement of the handles in opening and closing the door is to be in the direction of door movement and is to be clearly indicated.

6.2.10 *(1/7/2011)*

As far as practicable, electrical equipment and components for watertight doors are to be situated above the bulkhead deck and outside hazardous areas and spaces.

6.2.11 *(1/7/2011)*

The enclosures of electrical components necessarily situated below the bulkhead deck are to provide suitable protection against the ingress of water.

6.2.12 *(1/7/2011)*

Electric power, control, indication and alarm circuits are to be protected against fault in such a way that a failure in one door circuit may not cause a failure in any other door circuit. Short-circuits or other faults in the alarm or indicator circuits of a door may not result in a loss of power operation of that door. Arrangements are to be such that leakage of water into the electrical equipment located below the bulkhead deck may not cause the door to open.

6.2.13 *(1/7/2011)*

A single electrical failure in the power operating or control system of a power-operated sliding watertight door may not result in a closed door opening. Availability of the power supply is to be continuously monitored at a point in the electric circuit as near as practicable to each of the motors required in [6.2.8]. Loss of any such power supply is to activate an audible and visual alarm at the central operating console at the navigation bridge and at the damage control station(s).

6.2.14 *(1/7/2011)*

The central operating console at the navigation bridge and at the damage control station(s) is to have a "master mode" switch with two modes of control:

- a "local control" mode which is to allow any door to be locally opened and locally closed after use without automatic closure, and
- a "doors closed" mode which is to automatically close any door that is open. The "doors closed" mode is to permit doors to be opened locally and is to automatically reclose the doors upon release of the local control mechanism.

The "master mode" switch is to normally be in the "local control" mode. The "doors closed" mode is to only be used in an emergency or for testing purposes. Special consideration is to be given to the reliability of the "master mode" switch.

6.2.15 *(1/7/2011)*

The central operating console at the navigation bridge and at the damage control station(s) is to be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light is to indicate a door is fully open and a green light is to indicate a door is fully closed. When the door is closed remotely the red light is to indicate the intermediate position by flashing. The indicating circuit is to be independent of the control circuit for each door.

6.2.16 *(1/7/2011)*

It is not to be possible to remotely open any door from the central operating console.

6.2.17 *(1/7/2011)*

All watertight doors are to be kept closed during navigation. Certain watertight doors may be permitted to remain open during navigation only if considered absolutely necessary; that is, being open is determined essential to the safe and effective operation of the ship's machinery or to permit crew normally unrestricted access throughout the service areas. Such determination is to be made by the Society only after careful consideration of the impact on ship operations and survivability. A watertight door permitted to remain thus open is to be clearly indicated in the ship's stability information and the damage control documentation and is always to be ready for immediate closure.

Table 3 : Requirements for openings and crossings in water (weather)tight elements for front line and second line ships *(1/1/2025)*

Interested element	Hatches and bolted closures	Doors, panels, Hatches	Portlights and sides-cuttles	Ventilation trunks	Engine inlets and discharges	Cable crossing	Pipe crossings
Decks							
B.D. **(4)**	yes	yes	not	yes	yes	yes	yes
Watertight deck **(4)**	yes	yes	not	yes	yes **(2)**	yes	yes
exposed decks	yes	yes	not	yes	yes	yes	yes
Bulkhead							
M.T.W.B	not	not **(5)**	not	not	not	yes	yes
A.T.W.B. (Between W.D. & B.D.)	yes	yes	not	yes	not	yes	yes
Shell							
below W.D.	not	not **(6)**	not **(7)**	not	not	not **(3)**	yes
between B.D. & W.D.	yes	yes	not	yes	not	yes	yes
between B.D. & exposed deks	yes	yes	yes	yes	yes	yes	yes
Other elements							
tanks	yes	not	not	not	not	yes	yes
Double Bottoms	yes	not	not	not	not	yes	yes
Watertight elements below W.D.	yes	yes	not	yes	not	yes	yes
Cofferdams	yes	not	not	not	not	yes	yes

(1) Submerged discharges are considered as pipe crossings.

(2) Provided that the watertightness of the between W.D. and bulkhead deck (B.D.) is assured.

(3) For particular applications (Sonar , Hull sensors, Ecosounders...).

(4) In case all the watertight main transversal bulkheads are extended, above the watertight deck (W.D.) up to the bulkhead deck (B.D.), by an auxiliary watertight bulkhead, the tightness integrity of the first is to be the same uo to the second.

(5) With the exception of the watertight door in the bulkhead bounding the stearing gear local. which is to be approved in the contract.

(6) Unless otherwise specified in the Regulatory Framework and in agreement with the Society, a watertight shell door for pilot embarkation may be fitted provided that a second inner watertight boundary is realised with a strength equivalent to one of the shell.

(7) Unless otherwise specified in the Regulatory Framework and in agreement with the Society, a sidescuttle for the inspection of the propeller may be fitted provided that it is realised with a strength equivalent to one of the shell. Furthermore, the sidescuttle is to be located in a watertight space of moderate volume not containing machineries essential for propulsion, steering and safety.

SECTION 2 COMPARTMENT ARRANGEMENT

1 Flooding management

1.1 Protection

1.1.1 The requirements for openings in watertight bulkhead and deck are given in Sec 1, [5].

1.1.2 All cables and piping penetrations in a flooded compartment and below the waterline when the ship heels to the maximum angle at the final stage of flooding (see Ch 1, Sec 2, [3.2.2], Ch 3, Sec 3, [2.4.8]), or the maximum angle of heel during intermediate stages of flooding determined as required in Ch 3, Sec 3, whichever is the greater, have to be watertight when closed to the maximum waterhead.

Where no information regarding the above angle of heel is available, the waterhead is determined to 1 m above the waterline at the final stage after damage when the ship heels to an angle of 20° or 0,5 m m above the waterline at the level of the bulkhead deck when the ship heels to an angle of 20°, whichever is the greater.

1.2 Detection

1.2.1 All compartments considered as floodable for the damage stability verification (see Ch 3, Sec 3) have to be provided with water level detectors.

1.2.2 The compartment flooding information have to be display to the Damage Control Room.

1.3 Pumping

1.3.1 Floodable dry spaces have to be provided with a fixed water pumping installation or access for movable pumps from above the damage control deck as defined in Ch 1, Sec 2, [6.5].

1.3.2 The pumping capacity shall be at least as required in Pt C, Ch 1, Sec 10, [6.6.3].

2 Cofferdams

2.1 Definition

2.1.1 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.

2.2 Cofferdam arrangement

2.2.1 *(1/7/2011)*
Cofferdams are to be provided between compartments intended for liquid hydrocarbons (fuel oil, lubrificating oil) and those intended for fresh water (drinking water for propelling machinery and boilers) as well as tanks intended for he carriage of liquid foam for fire extinguishing between service tanks and shell below the deepest waterline, between ammunition stores and rooms where heating sources are present.

2.2.2 *(1/1/2025)*
Furthermore, tanks carrying fresh water for human consumption are to be separated from other tanks containing substances hazardous to human health by cofferdams or, when deemed impracticable or unreasonable by the Society in relation to the characteristics and dimensions of the spaces containing such tanks, by other means such as those foreseen in [2.2.3].

2.2.3 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.

2.2.4 *(1/1/2025)*
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.

2.2.5 *(1/7/2011)*
For JP5-NATO (F44) tanks arrangement see also Pt C, Ch 4, Sec 10, [4.1].

3 Ballast compartments

3.1 General

3.1.1 Water ballast may not be carried in tanks intended for fuel oil.

4 Double bottoms

4.1 Auxiliary ships

4.1.1 A double bottom is to be fitted extending from the collision bulkhead to the after peak bulkhead, as far as this is practicable and compatible with the design and proper working of the ship.

4.2 Front and second line ships

4.2.1 A double bottom is required as far as practicable within the machinery spaces.

5 Compartments forward of the collision bulkhead

5.1 General

5.1.1 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.

6 Minimum bow height

6.1 General

6.1.1 *(1/1/2025)*

The bow height F_b is, defined as the vertical distance at the forward perpendicular between deepest full load line and the top of the exposed deck at side, is to be not less than:

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

where:

F_b : calculated minimum bow height, in mm

T_1 : draught at 85% of the least moulded depth D1, 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 bulkhead 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 uppermost continuous 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:

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

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

∇ : volume of the moulded displacement, excluding appendages, in m^3, at draught T_1.

6.1.2 When operational speed versus sea state conditions are specified, the criteria, the verification method and verification results of the bow height adequacy will have to be submitted to the society.

7 Machinery compartments

7.1 General

7.1.1 When longitudinal bulkheads are fitted in the machinery space, adequate self-operating arrangements are to be provided in order to avoid excessive heel after damage.

Where such arrangements are cross-flooding system, their area is to be calculated in accordance with the requirements in Ch 3, App 3. In addition, such systems are to comply with the criteria in Ch 3, Sec 3.

7.2 Two compartments

7.2.1 When the ship is fitted with two machinery compartments, the requirements in Sec 1, [4.1.1] are to be applied.

8 Shaft tunnels

8.1 General

8.1.1 Shaft tunnels are to be watertight to possible internal flooding.

9 Watertight ventilators and trunks

9.1 General

9.1.1 Watertight ventilators and trunks are to be carried at least up to a level where no flooding can occur in damage intermediate and final condition (see Ch 3, Sec 3, [2.4.6]).

10 Fuel oil tanks

10.1 General

10.1.1 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.

10.1.2 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 as defined in Ch 1, Sec 2, [7.2].

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.

10.1.3 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.

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

11 Ammunition storage compartments

11.1 General

11.1.1 *(1/1/2025)*

Particular care has to be taken for the arrangement of ammunition storage compartments to prevent risk of explosion.

SECTION 3 ACCESS AND OPENINGS 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 or 500 x 380 clear light. 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 Cargo holds, tanks, water ballast tanks and cofferdams

3.1 General

3.1.1 Cargo holds, tanks, water ballast tanks, cofferdams are to be served by at least one access hatchway and ladder.

3.1.2 External openings required to be watertight are to be of sufficient strength and, except for hatch covers, are to be fitted with indicator in the safety control room

3.2 Access through decks

3.2.1 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 compartment. In no case is the clear opening to be less than 600 mm x 600 mm.

3.2.2 Opening protection

If an access is to remain open for operational efficiency, it is to be fitted with a light panel to prevent falls of a person when the hatchway remains open.

3.3 Access within tanks

3.3.1 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.

3.3.2 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.

3.4 Construction of ladders

3.4.1 General

In general, the ladders are to be either vertical or inclined at an angle not exceeding 65°. 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.

Side stringers are to be flat bars of not less than 60 mm by 6 mm in section.

3.4.3 Width of ladders

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

3.4.4 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 16 mm by 16 mm in section fitted to form a horizontal step with the edges pointing upward, or of equivalent construction. The treads are to be welded to the side stringers.

3.4.5 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 Air pipes

4.1 General

4.1.1 Internal open end of air pipes *(1/7/2011)*

The open end of air pipes terminating within a superstructure is to be at least 1 m above the waterline when the ship heels to an angle of 15 degrees, or the maximum angle of heel during intermediate stages of flooding, as determined by direct calculation, whichever is the greater.

Where no information regarding the above angle of heel is available, the open end of air pipes terminating within a superstructure is to be at least 1 m above the waterline at the final stage after damage when the ship heels to an angle of 20° or 0.5 m above the waterline at the level of the bulkhead deck when the ship heels to an angle of 20°, whichever is the greater.

Part B
Hull and Stability

Chapter 3
STABILITY AND SEA-KEEPING

SECTION 1 GENERAL

1 Definitions

1.1 Definitions

1.1.1 General

Otherwise specified, the definitions of the parameters and ship components mentioned in this chapter are given in Ch 1, Sec 2.

2 General

2.1 Application

2.1.1 General

All ships may be assigned class only after it has been demonstrated that their intact and damage stability is adequate for the service intended.

Otherwise specified, adequate intact and damage stability means compliance with the requirements specified in this Chapter taking into account the ship's size and type. In any case, the level of intact and damage stability is not to be less than that provided by the rules of Sec 2 and Sec 3.

2.1.2 Approval of the Naval Administration *(1/1/2025)*

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

3 Examination procedure

3.1 Documents to be submitted

3.1.1 List of documents

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, as indicated in Ch 1, Sec 3, is as follows:

- Inclining ligthship 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
- trim and stability booklet, as required in App 2.
- damage stability calculations, as required in Sec 3, [1.1.1]
- loading computer documentation, as required in Sec 2, [1.1.3] and in Sec 3, [1.1.2]

and for examination:

- damage control documentation, as required in Sec 3, [1.2].

A copy of the trim and stability booklet, the damage control documentation and 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.

3.2 Inclining test/lightweight check

3.2.1 Definitions

a) Lightweight

   The light ship weight definition is given in Ch 1, Sec 2, [5.1].

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 relevant to the actual trim and the sea water density.

3.2.2 General

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

3.2.3 Inclining test (1/1/2025)

The inclining test is required in the following cases:

- Any new ship, after its completion.
- Any ship, if deemed necessary by the Society, where any alterations are made so as to materially affect the stabilityFor 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 Detailed procedure

A detailed procedure for conducting an inclining test and the lightweight is included in App 1.

SECTION 2 INTACT STABILITY

1 General

1.1 Information for the Master

1.1.1 Stability booklet (1/1/2017)

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 10, Sec 2, [4.5]).

Where any alterations are made to the 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 at least in English.

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 Periodical lightweight and stability check (1/1/2017)

At periodical intervals not exceeding five years, a lightweight survey shall be carried out on all ships to verify any changes in lightship displacement and longitudinal centre of gravity.

The ship shall be re-inclined whenever, in comparison with the approved stability information, a deviation from the lightship displacement exceeding 2% or a deviation of the longitudinal centre of gravity exceeding 1% of LBP is found or anticipated.

The full process as defined in App 1 has to be applied.

1.1.3 Loading instrument (1/1/2017)

As a supplement to the approved stability booklet, a loading instrument, approved by the Society, when specified in the Regulatory Framework Pt A, Ch 2, App 1, may be provided 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 hardware and 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 10, Sec 2, [4].

1.2 Conditions and criteria

1.2.1 The requirements of this section concerns ship loading and environmental conditions, criteria to be fulfilled can be modified with respect to the ship service notation as given in Part D of the Rules for the Classification of the Ships.

1.3 Permanent ballast

1.3.1 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.

1.3.2 No liquid permanent ballast is allowed.

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

2 Design criteria

2.1 General intact stability criteria

2.1.1 General (1/1/2017)

The intact stability criteria specified in [2.1.2] to [2.1.5] are to be complied with for the loading conditions mentioned for project verification in Ch 1, Sec 2, [5.2], Ch 1, Sec 2, [5.3] and App 2, [1.1.2].

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

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 Elements affecting stability (1/1/2017)

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.

2.1.3 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 and to loss as of weight such as those due to consumption of fuel and stores.

All deck areas where water can be trapped will have to be considered with the maximum possible water level.

Effect of ship turning, crowding of passengers, wind and rolling, liquid free surfaces, icing, cargo lifting are covered by [2.1.2] to [2.1.5].

The intact stability characteristics of the ships shell be investigate through the following analysis:

a) righting arms (GZ curve) of the ship in the several loading condition;

b) behaviour of the ship under heeling actions as:

   1) severe wind and rolling

   2) icing accretion

   3) high speed turning

   4) heavy cargo lifting

   5) crowding of the personal through a side of the ship

   6) contemporary action of wind and the personal crowding.

The requirement of the reactions of the ship to the above heeling actions and the criteria which the vessel has to comply with are dependent on her type.

2.1.4 Ship mass evolution (1/1/2025)

Unless otherwise specified in the Regulatory Framework, the stability has to be assessed taking into account a total mass evolution at end of life as follows:

- 3,0 % of growth in light ship displacement in respect of the light ship displacement at delivery;
- 1,0 % of rise of the position of the centre of gravity in respect of the height of centre of gravity in the light ship at delivery.

2.1.5 Definition of angles of arms curves

θ_d : Ultimate angle of dynamic stability.

It is the angle over which the reserve of dynamic stability isn't not sufficient any more (the dynamic capsizing happens) to face a constant inclining moment (invariable with the heeling), suddenly applied to the ship. Its value corresponds to that of the angle at which the value of the area A is the same of the value of the area B (Fig 1).

θ_0 : Limit of static stability.

It is the angle corresponding to the maximum heeling moment (this moment is applied to the ship increasingly to the purpose of avoiding all the dynamic effects) which the ship may face before the capsizing.

θ_s : Capsizing angle (over this angle the capsizing of the ship happens even if the inclining moment disappears.

θ_f : Flooding angle (is the lowest angle at which the first opening not closed, is reached).

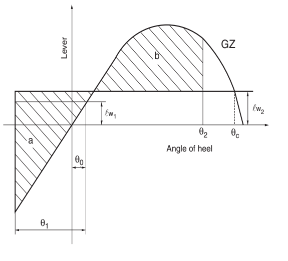
This is the angle corresponding to the minimum angle of heel to which at least one unprotected point (see [2.1.6]) is immersed.

θ_r : Rolling angle.

θ_c : Static equilibrium angle caused by an external action.

θ_e : Equilibrium angle after damage (without external actions).

Figure 1 : Righting arms curve



2.1.6 Location of the flooding angle

The points of flooding are only the unprotected points which may endanger the stability or the efficiency of the ship (openings leading to large volumes and of size such that the emptying means present on board are not sufficient to face the input of sea water through them), i.e. , ventilators in E.R. (Fig 2, Fig 3 and Fig 4).

In the case of a trunk supplied with a closure device or an on-off valve two cases may rise:

a) Either the devise, or the valve are proper for the hydrostatic head correspondent to a heeling angle of 70°; in such case the trunk is not considered a point of flooding unprotected.

b) Either the device, or the valve are proper for a hydrostatic head h lesser then that of the point a). In such case the point of flooding has to be positioned raised of the value h.

Figure 2

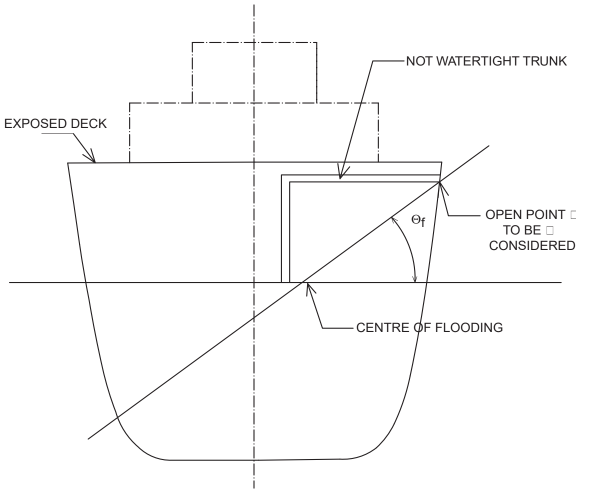


Figure 3

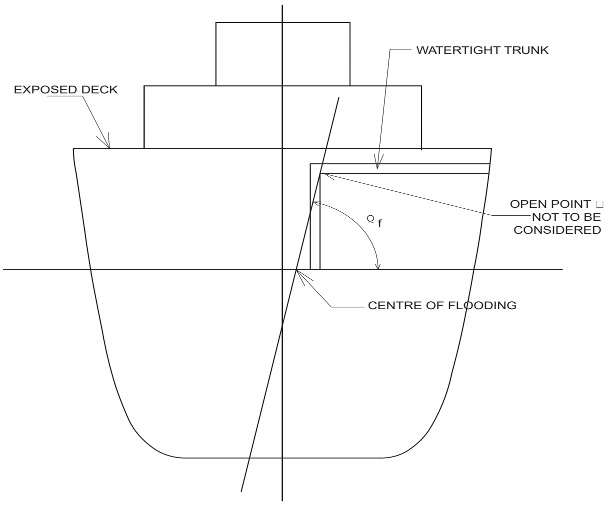
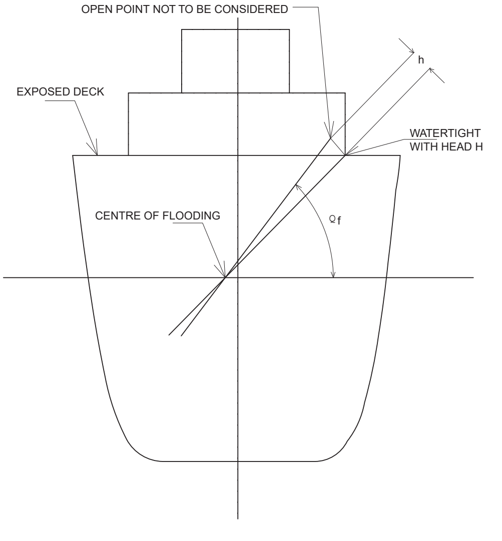


Figure 4



2.1.7 Righting arms curve

In creating the righting arms curve, the following rule have to be taken into account: the calculation through which the values of the righting arms for the considered heeling angles is to be carried out taking in account the change of trim and the free surface effects.

The arms curve has to be stopped when the smallest of the following values is reached:

a) 70°

b) θ_f = angle at which openings not supplied with at least weathertight devices remain submerged

c) θ_s = capsizing angle.

2.1.8 Requirements for the righting arms curve

The righting arms curve shall to achieve at least the requirements listed in Tab 1 and represented in Fig 5.

The maximum value of the righting arms (GZ_{Max}) is described in Fig 6 and shall be, in any case within 30° and 50°.

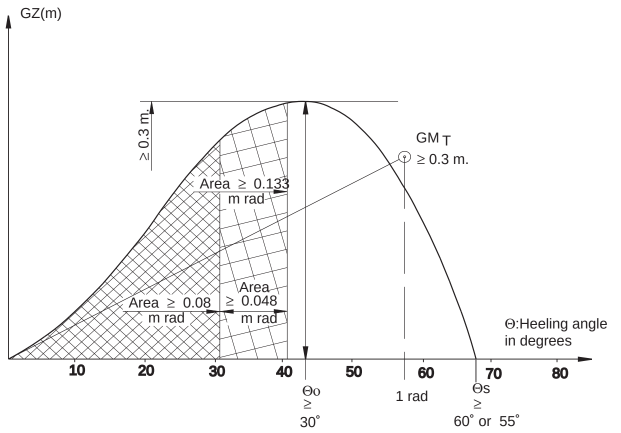
The criteria reported in Tab 1 define the minimum requirements, not the maximum.

Anyway is recommended not to exceed with the value of GM to the purpose of avoid high dangerous accelerations.

Table 1 : Minimum values required for the righting arms curve in intact condition

Area under the righting arm curve (GZ) up to 30° or θ_f	Not less than 0,080 m rad (15 feet degree)
Area under the righting lever (GZ) up to 40° or θ_f	Not less than 0,133 m rad (25 feet degree)
Area under the righting arm curve (GZ) between 30° and 40°	Not less than 0,048 m rad (9 feet degree)
Value of the maximum righting arm curve	Not less than 0,3 m (1 foot)
Heeling angle corresponding to the maximum righting arm curve (GZ_{Max})	Not less than 30°
Value of the initial metacentric height corrected for free surface effect (GM_{corr})	Not less than 0,3 m (1 foot)
Value of the capsizing angle (θ_s)	Higher than 60° for ships with Lightship displacement less than 5000 t Higher than 55° for ships with lightship displacement not less than 5000 t

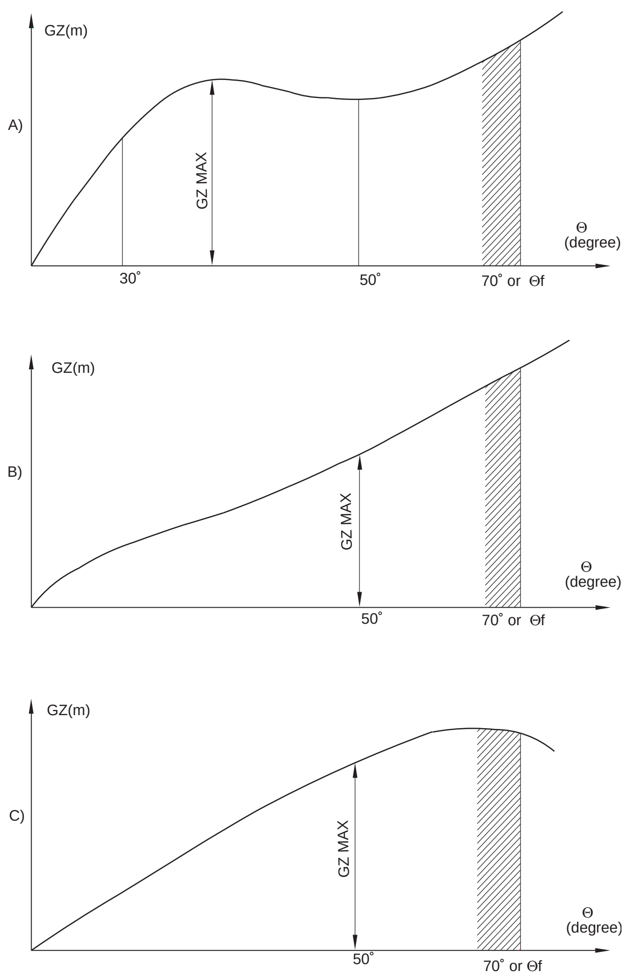
Figure 5



Θo = Extreme angle of static stability

Θs = Capsizing angle

Figure 6



Note: If Θf < 50°, the value of GZMax is to be considered between 30° and Θf

2.2 Effect of free surfaces of liquids in tanks

2.2.1 Tanks for liquids

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.

2.2.2 Decks

Decks are provided with efficient drainage arrangement to prevent accumulation of entrapped water due to weather conditions, cleaning or fire fighting.

If the drainage arrangement are not considered efficient by the Society, free surface effects may be required, case by case, for the stability calculations.

2.2.3 Consideration of free surface effects (1/1/2017)

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 normally 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.

Free surface effects for small tanks may be ignored under the condition in [2.2.10].

2.2.4 Categories of tanks

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 cargo transfer operations). Except as permitted in [2.2.6] and [2.2.7], the free surface correction is to be the maximum value attainable among the filling limits envisaged for each tank, consistent with any operating instructions.

2.2.5 Consumable liquids

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.

2.2.6 Water ballast tanks

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.

2.2.7 Liquid transfer operations (1/1/2017)

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, at the discretion of the Society.

2.2.8 GM_0 and GZ curve corrections (1/1/2017)

The corrections to the initial metacentric height and to the righting lever curve are to be addressed separately as indicated in a) and b) below.

a) In determining the correction to the initial metacentric height, the transverse moments of inertia of the tanks are to be calculated at 0° angle of heel according to the categories indicated in [2.2.4].

b) 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, or
   - Correction based on the moment of inertia, calculated at 0° angle of heel, modified at each angle of heel calculated;
   - Corrections may be calculated according to the categories indicated in [2.2.4].

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.

2.2.9 Remainder of liquid

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.

2.2.10 Small tanks

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

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

where:

Δ_{min} : Minimum operational condition ship displacement in t (Ch 1, Sec 2, [5.4.1])

2.3 Severe wind and rolling

2.3.1 Purpose

A vessel has to be able to withstand weather and marine adverse conditions without risk the own safety.

The wind and rolling verification ensure a good level of safety for such condition.

The speed of the wind is ruled in Tab 2.

Table 2 : Theoretical speed of the wind *(1/1/2017)*

Service	Minimum wind velocity
UNRESTRICTED Ships which may be expected to face any weather conditions encountered. Ships which may be expected to avoid extreme conditions	 100 knots 80 knots
Summer Zone	80 knots
Tropical Zone	60 knots
Offshore Navigation	60 knots
Coastal area	50 knots
Sheltered Area	40 knots
Special navigation	To be defined on a case by case basis
Note 1: In general first line ships may be expected to face any weather conditions encountered and auxiliary ships may be expected to avoid extreme conditions. Second line ships should be defined on a case by case basis, taking into account the service requested.	

2.3.2 Stability requirements

The wind and rolling verification shell be carried out by comparing the righting arms curve and the heeling arms curve.

The characteristics of speed and distribution of wind are specified in [2.3.3].

2.3.3 Wind speed *(1/7/2011)*

The wind action shell be considered cross directed, its speeds are those reported in Tab 2.

Special consideration will be given to existing ships.

The heeling action of the wind is to be carried out according to App 5.

2.3.4 Dynamic effects

To the purpose of taking account of the heeling caused by wind combined with rolling, the value of the heeling arm GZ_1 in the proximity of the angle of static equilibrium (θ_C) has to be less than the maximum value of the righting arm (GZ_{Max}) at least of 40%.

2.3.5 Rolling and reserve of stability

The value of the rolling angle used for the check shall be 25°.

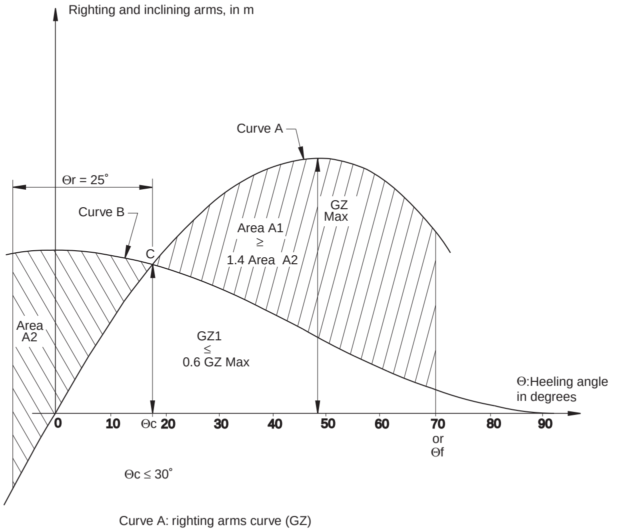
The ship is considered in condition of static equilibrium (point C of the Fig 7); from that point a rolling angle of 25° is taken into account.

The following areas are considered:

- "A2" Heeling area
- "A1" Rigthing area

To ensure a sufficient level of safety, the area "A1" shall be at least 40% higher than area "A2".

Figure 7



2.3.6 Maximum value of the angle of static equilibrium

The maximum allowable value of the static equilibrium (θ_C) is 30°.

That to be sure that the vessel operates safely.

2.3.7 Summary of the stability requirements for wind and rolling

The stability requirements for wind and rolling actions are the following:

a) $GZ_1 \leq 0,6\ GZ_{Max}$

b) $A_1 \geq 1,4\ A_2$

c) $\theta_C \leq 30°$

2.4 Icing

2.4.1 General

For ships which may operate in areas North of latitude 65° and South of latitude 60° and anyway in seas where icing, in winter periods, is expected, the heeling actions due to icing accretion on superstructures and decks, has to be taking into accoun.

In such areas an icing mass is expected in the more exposed zones of the ship to the adverse conditions (fore part), with the triple effect of:

- Increasing of displacement.
- Trim changing.
- Centre of gravity elevation.

2.4.2 Calculation assumption

To the purpose of evaluate the stability of a vessel in the condition of ice accretion, the following procedure has to be followed:

a) The curve of righting arms relevant to the loading conditions altered by the ice accretion mass (as after settled) taking account of the free surfaces effects.

b) The check of the stability of the ship under the combined action of wind and rolling, similarly to [2.3], but taking into account values of wind speeds, 30% less than those in Tab 2.

In the vessels where devices for removing ice are available, the action of such devices has to be disregarded.

2.4.3 Guidance relating to icing accretion

For ships with lightship displacement not higher than 1000 t, the icing mass to charge is 10% of its full load displacement.

For ships with lightship displacement higher than 1000 t, the icing mass to charge is established as follows:

- Just the fore third of the length of the vessel, above the waterline, including the sides are to taken into account.

A uniform icing mass, of 140 Kg/m^2 for the horizontal areas and 70 Kg/m^2 for the vertical or oblique areas, has to be considered embarked.

2.4.4 Centre of gravity of icing accretion

For ships with lightship volume not higher than 1000 t, the centre of gravity of the icing accretion has to be considered coincident with the centre of gravity of the ship in the several loading conditions.

For ships with lightship volume higher than 1000 t, the centre of gravity of the icing accretion has to be considered in its own position.

2.4.5 Stability requirements for icing

The righting arms curve is to be in accordance with the requirements of Tab 3 and Fig 9.

The following criteria have to be complied for heeling due to wind and roll.

a) $GZ_1 \leq 0,6\ GZ_{Max}$

b) $A_1 \geq 1,4\ A_2$

c) $\theta_C \leq 30°$

See Fig 8.

2.5 High speed turning

2.5.1 Introduction

When the ship turns at high speed, an inclining moment arises which may be prominent.

The purpose of the stability checking for high speed turning is the behaviour of the vessel in such occasion.

2.5.2 High speed turning

The inclining lever (IL), to be considered in the comparing with the righting levers curve, is obtained with the formula:

$$IL = \left(\frac{V^2}{R}\right) \cdot \left(\frac{a\cos\theta}{g}\right)$$

where:

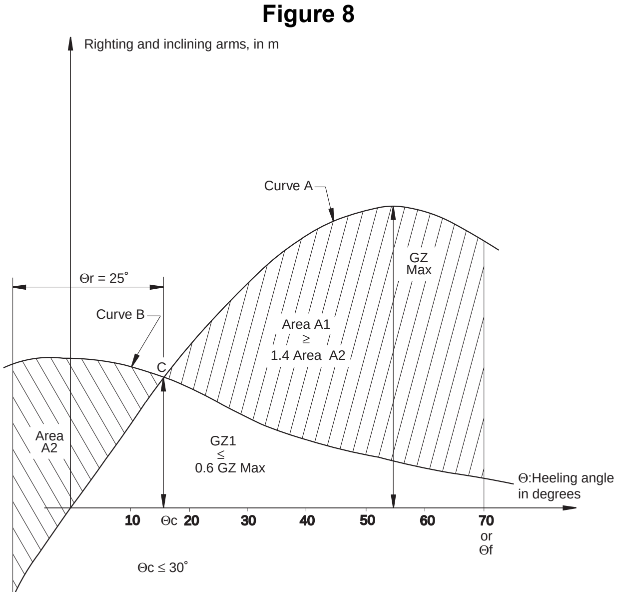
- V : Speed, in m/sec of the vessel in the turning operating. Such value may be assumed 80% of the maximum speed.
- R : Turning radius, in m (if unknown, it may be assumed $3,3L_{BP}$).
- g : Gravity acceleration.
- a : Vertical distance, in m, between the centre of gravity of the vessel and its drifting centre (if unknown it may be taken the half of mean draught).
- θ : Heeling angle, if degrees.

Table 3 : Requirement for righting lever curve for the loading conditions with icing accretion

Area under the righting lever curve (GZ curve) up to 30°, or θ_C, if less than 30°	Higher than 0,051 mrad (9,60 feet-degrees)
Area under the righting lever curve (GZ curve) up to 40°, or θ_C, if less than 40°	Higher than 0,085 mrad (16 feet-degrees)
Area under the righting lever curve (GZ curve) between the angles of heel 30° and 40°, or θ_C, if less than 40°	Higher than 0,033 mrad (5,76 feet-degrees)
The maximum righting lever GZ	At least 0,24 m (0,8 feet)
Heeling angle corresponding to the maximum righting arm (GZ_{Max})	If higher than 30° (could not less than 25°)
Initial metacentric height (liquid) corrected for the actions of free surfaces moments (Gm_{corr})	Not less than 0,15 m (0,5 feet)

See Fig 9.

Figure 8



Curve A: righting arms curve corrected for icing

Curve B: wind inclining arms

Figure 9

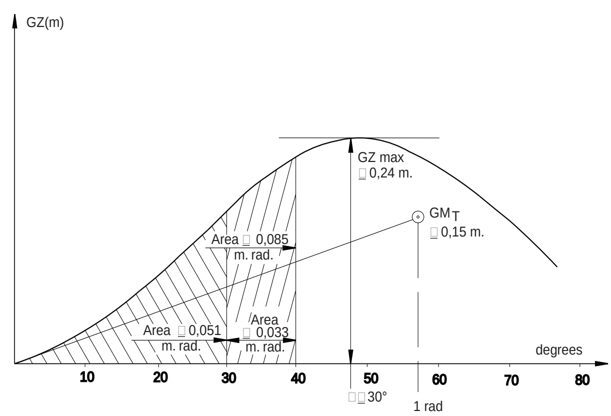
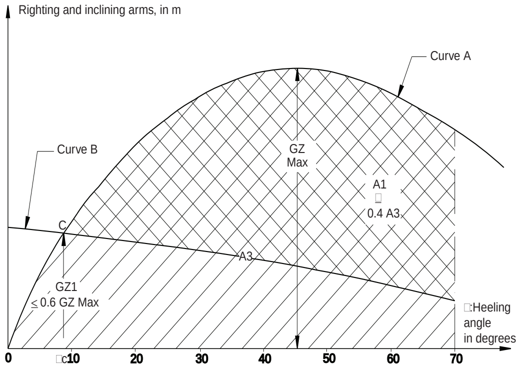


Figure 10



Curve A: righting arms curve of the ship in the intact condition

Curve B: inclining arms curve for evolution at high speed

A1: area between righting curve (A curve) and inclining curve (B curve)

A3: total area below the righting arms curve

2.5.3 Requirements for high speed turning

The stability requirements for high speed turning are the following (see Fig 10):

a) $GZ_1 \leq 0{,}6\ GZ_{Max}$

b) $A_1 \geq 0{,}4\ A_3$

c) $\theta_C \leq 15°$

Note 1: Such value corresponds to the maximum value of the equilibrium angle corresponding to that allowable for a good working of the essential devices of the vessel.

The θ_C value may be reduced to 10°.

2.6 Heavy cargo lifting in still water

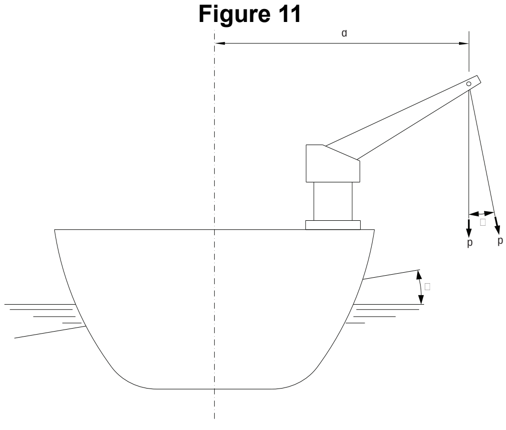
2.6.1 The lifting of weights is a decisive factor in checking the stability of a vessel of small dimensions.

In fact the lifted mass, applied to the upper end of the derrick, raises the centre of gravity, reducing, consequently, the value of the initial metacentric height (see Fig 11).

The present paragraph deels with raising of weights in still water.

It is strongly suggested to avoid raising of weights in rough sea. For that, if essential, particular considerations are required.

Figure 11



2.6.2 Intact stability criteria

Two cases may arise:

a) The weight of the cargo is known. In such a case the stability requirements of the following [2.6.3] are to be complied with.

b) The weight of the cargo is unknown. In such a case the [2.6.3] maximum allowable weight, complying with the requirements, is to be carried out.

In both the above cases, the righting arms curve (GZ) built, taking into account of the increasing of: displacement, raising of the centre of gravity and conditions set up in [2.1.7], have to be compared with the heeling arms curve carried out according to the formula:

$$H_a = \frac{p\ d \cos\theta}{\Delta}$$

where:

- H_a : Heeling arms, in m.
- p : Weight to be raised, in t.
- d : Transversal distance, in m, between the centreline of the ship and the more external end of the derrick.
- Δ : Displacement, in t, of the ship with the raised weight.
- θ : Heeling angle, in degrees.

2.6.3 Requirements

To comply the stability criteria, the vessel has to meet the following requirements (see Fig 12):

a) The value of the static equilibrium caused by the heeling for the cargo raising has to be not more than 15°, or the value of dynamic equilibrium angle θ_d (see [2.1.5]) if less:

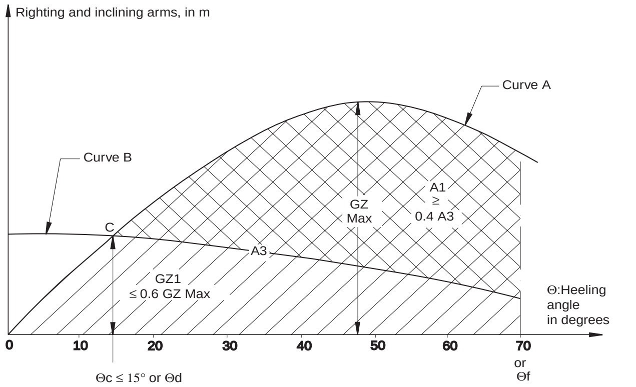
$\theta_c \leq \min(15°, \theta_d)$

b) $GZ_1 \leq 0{,}6\ GZ_{Max}$ (as in [2.3.4])

c) The value of the area of the residual stability diagram, represented as area A1 in Fig 12 has to be not less than 40% of the total area below the stability curve, represented by A_3 area of the Fig 12 .

$A_1 \geq 0{,}4\ A_3$

Figure 12



Curve A: - Curve A: righting arms curve of the ship in the intact condition, taking into account the increase in the displacement and in the centre of gravity height

Curve B: inclining arms curve due to cargo lifting

A1: area between righting curve (A curve) and inclining curve (B curve)

A3: total area below the righting arms curve

2.7 Crowding of personnel on a side

2.7.1 Introduction

The crowding of personnel (as defined in Ch 1, Sec 2, [7.4.1]) on a vessel of small dimensions where a large number of personnel is embarked may be cause of stability problems. In fact the crowding on a side of the vessel causes a heeling moment which produces a considerable reduction of the dynamic stability reserve.

2.7.2 Stability calculations: Assumptions

All the personnel is are considered crowded on the upper deck to them assigned and as more as possible at side, taking into account the following requirements:

a) 4 persons for square metre;

b) mean weight of each person 75 Kg.

The heeling arms curve will be calculated (see following [2.7.3]) and compared with righting lever curve as defined in [2.1.7].

2.7.3 Stability calculations: Heeling arms

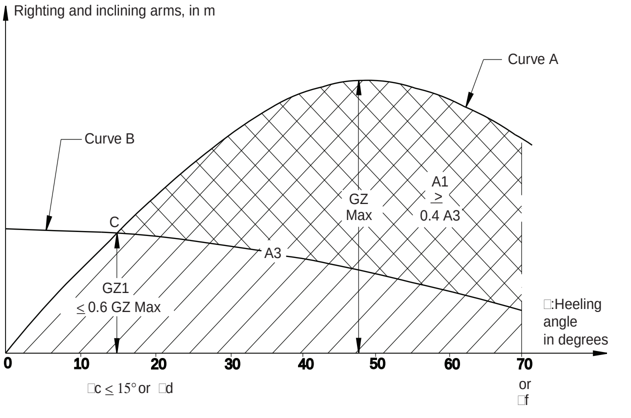
The heeling arms (see Fig 13) caused by the transversal movement of personnel is calculated by the following formula:

$$H_a = \frac{p\ d\cos\theta}{\Delta}$$

where:

- H_a : Heeling arms, in m.
- p : The weight of moved personnel, in t.
- d : Transversal distance, in m, from the centre line of the ship to the centre of gravity of the area in which the personnel are crowed.
- Δ : Displacement of the ship, in t.
- θ : Heeling angle, in degrees.

Figure 13



Curve A: righting arms curve of the ship in the intact condition

Curve B: inclining arms curve due to personnel crowding

A1: area between righting curve (A curve) and inclining curve (B curve)

A3: total area below the righting arms curve

2.7.4 Required criteria

To the purpose to fulfil the stability criteria, the vessel has to comply with the following requirements (see Fig 13):

a) The value of the static equilibrium angle (θ_c) caused by the crowding of personnel at side have to be not higher than 15° or dynamic equilibrium angle θ_d (see [2.1.5]) if less:

   $\theta_c \leq \min(15°, \theta_d)$

b) $GZ_1 \leq 0,6\ GZ_{Max}$

c) The value of the area of the residual stability diagram, consequent to the crowding of personnel at side, represented as area A_1 in Fig 13 has to be higher than 40% of the total area below the stability curve, represented by A_3 area in the same figure.

   $A_1 \geq 0,4\ A_3$

SECTION 3 DAMAGE STABILITY

1 General

1.1 On board supports

1.1.1 Damage stability documentation

For all ships documents including damage stability calculations are to be submitted.

The damage stability calculations are to include:

a) list of characteristic (volume, centre of gravity, permeability) of each compartment which can be damaged;

b) a table of openings in bulkheads, decks and side shell reporting all the information about:
   - identification of the opening
   - vertical, transverse and horizontal location
   - type of closure: sliding, hinged or rolling for doors
   - type of tightness: watertight, weathertight or unprotected
   - operating system: remote control, local operation, indicators on the bridge, television surveillance, water leakage detection, audible alarm, as applicable; foreseen utilisation: open at sea, normally closed at sea, kept closed at sea.

c) list of all damage cases corresponding to the applicable requirements;

d) detailed results of damage stability calculations for all the loading conditions foreseen in the applicable requirements;

e) the limiting GM/KG curve, if foreseen in the applicable requirements;

f) capacity plan;

g) arrangement of cross flooding, pipes showing location of remote controls for valves, or special mechanical means to correct list due to flooding, if any;

h) watertight and weathertight door plan.

1.1.2 Loading instrument

As a supplement to the approved damage stability documentation, a loading instrument, approved by the Society, has to be provided to facilitate the damage stability calculations mentioned in [1.1.1].

The following loading instrument documentation has to be provided:

- loading instrument approved by Society;
- on board user's manual for examination.

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 10, Sec 2, [4.6].

1.2 Damage control

1.2.1 Documentation to be supplied

The Master of the ship is to be supplied with the data necessary to maintain sufficient intact stability under service conditions to enable the ship to withstand the critical damage. In the case of ships requiring cross-flooding, the Master of the ship is to be informed of the conditions of stability on which the calculations of heel are based and be warned that excessive heeling might result should the ship sustain damage when in less favourable condition.

The data referred to above, to enable the Master to maintain sufficient intact stability, are to include information which indicates the maximum permissible height of the ship's centre of gravity above keel (KG), or alternatively, the minimum permissible metacentric height (GM) for a range of draught or displacements sufficient to include all service conditions. The information is to show the influence of various trims taking into account the operational limits.

1.2.2 Damage control documentation *(1/1/2017)*

The damage control documentation is to include a damage control plan which is intended to provide ship's officers with clear information on the ship's watertight compartmenting and equipment related to maintaining the boundaries and effectiveness of the compartmentation so that, in the event of damage causing flooding, proper precautions can be taken to prevent progressive flooding through openings there in and effective action can be taken quickly to mitigate and, where possible, recover the ship's loss of stability.

The damage control documentation is to be clear and easy to understand. It is not to include information which is not directly relevant to damage control, and is to be provided in the language or languages of the ship's officers. The languages used in the preparation of the documentation is to be at least English.

Plans showing clearly for each deck and hold the boundaries of the watertight compartments, the openings therein with the means of closure and position of any controls thereof, and the arrangements for the correction of any list due to flooding are to be permanently exhibited for the guidance of the officer in charge of the ship. In addition, booklets containing the aforementioned information are to be made available to the officers of the ship.

Watertight doors that may be permitted to remain open during navigation are to be indicated in the damage control plan with the indication that "doors are always to be ready for immediate closure", Detailed description of the information to be included in the damage control documentation is reported in [2.4].

IMO MSC.1/Circ 1245, as may be amended, may be taken into account as guideline for drafting damage control documentation

1.2.3 Draught marks

Each ship is to be provided with scales of draughts marked clearly at the bow and stern. In the case where the draught marks are not located where they are easily readable, or operational constraints trade make it difficult to read the draught marks, then the ship is also to be fitted with a reliable draught indicating system by which the bow and stern draught can be determined.

2 Conditions and criteria

2.1 Approaches to be followed for damage stability investigation

2.1.1 General

Damage stability calculations are required in order to achieve a minimum degree of safety after flooding.

The metacentric height (GM), stability levers (GZ) and centre of gravity positions for judging the final surviving conditions are to be calculated by the constant displacement (lost buoyancy) method.

2.1.2 Methodology

The approach is based on standard dimensions of damage extending anywhere along the ship's length or between transverse bulkheads depending on the relevant requirements.

The consequence of such standard of damage is the creation of a group of damage cases, the number of which, as well as the number of compartments involved in each cases, depend on the ship's dimensions and internal subdivision.

For each loading condition, each damage case is to be considered, and all the applicable criteria are to be complied with.

2.2 Progressive flooding

2.2.1 Definition

Progressive flooding is the additional flooding of spaces which were not previously assumed to be damaged. Such additional flooding may occur through openings or pipes as indicated in following [2.2.2] and [2.2.3] which are located below the water lines of the final and intermediate stages of flooding.

2.2.2 Openings *(1/1/2007)*

The openings may be listed in the following categories, depending on their means of closure:

a) Unprotected

   Unprotected openings are openings which are not fitted with at least weathertight means of closure.

   Unprotected openings which are located below the waterline after damage (at any stage of flooding) are not allowed; see also [2.4.6] a).

b) Weathertight

   Openings fitted with weathertight means of closure are not able to sustain a constant head of water, but they can be intermittently immersed within the positive range of stability.

   Weathertight openings may lead to progressive flooding if they are located below the final waterline after damage.

c) Watertight

   Internal openings fitted with watertight means of closure are able to sustain a constant head of water corresponding to the distance between the lowest edge of this opening and the bulkhead deck.

   Air pipe closing devices may not be considered watertight, unless additional arrangements are fitted in order to demonstrate that such closing devices are effectively watertight.

   The pressure/vacuum valves (PV valves) currently installed on tankers do not theoretically provide complete watertightness.

   Manhole covers may be considered watertight provided the cover is fitted with bolts located such that the distance between their axes is less than five times the bolt's diameter.

   Access hatch covers leading to holds may be considered watertight.

   Watertight openings do not lead to progressive flooding.

2.2.3 Pipes

Progressive flooding through pipes may occur when:

a) the pipes and connected valves are located within the assumed damage, and no valves are fitted outside the damage

b) the pipes, even if located outside the damage, satisfy all of the following conditions:

   - the pipe connects a damaged space to one or more spaces located outside the damage
   - the highest vertical position of the pipe is below the waterline, and
   - no valves are fitted

The possibility of progressive flooding through ballast piping passing through the assumed extent of damage, where positive action valves are not fitted to the ballast system at the open ends of the pipes in the tanks served, is to be considered. Where remote control system are fitted to ballast valves and these controls pass through the assumed extend of damage, then the effect of damage to the system is to be considered to ensure that the valves would remain closed in that event.

If pipes, ducts or tunnels are situated within assumed flooded compartments, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed flooded.

2.3 General

2.3.1 Loading conditions

The damage stability criteria specified in [2.4] are to be complied with for the loading conditions mentioned in App 2, [1.2] and the loading conditions allowing to take into account the possible evolution of mass during the ship life as given in Sec 2, [2.1.2].

However, the lightship condition not being an operational loading case, no verification are required for this case.

2.3.2 Calculation assumptions

Calculations which are to be performed in accordance with [2.4.2] to [2.4.7] and will take into consideration the proportions and design characteristics of the ship and the arrangement and configuration of the damaged compartments. In making these calculations the ship is to be assumed in the worst anticipated service condition as regards stability

Effects of free surfaces of liquids in tanks have to be taken into account as defined in Sec 2, [2.2],

Damaged compartments, when filled of liquid, will be subject to run-off, when relevant.

Where it is proposed to fit decks, inner skins or longitudinal bulkheads of sufficient tightness to seriously restrict the flow of water, the Society is to be satisfied that proper consideration is given to such restrictions in the calculations.

2.4 Damage and criteria

2.4.1 Introduction

The present section defines the stability requirements to be complied when a ship is in damage conditions.

The compliance to such requirements assumes the floating of the ship after several damage cases and the survival such that the return to the harbour is possible.

2.4.2 Damage *(1/1/2017)*

The damage to take into account is a continue breach in the hull of the ship.

The damage is applied anywhere within the ship's length L_{BP}.

All positions of the damage along the ship are to be considered.

a) Longitudinal damage extension

The longitudinal extension of the damage causes the flooding of two main adjacent watertight compartments as defined in Ch 1, Sec 2, [6.7] (see Fig 1).

b) Vertical damage extension

The vertical extension of the damage as to be such that all decks closures and platforms within the damaged area are destroyed (see Fig 3).

c) Transveral damage extension

The transversal extension of the damage may reach the centre line of the ship without nevertheless including it (see Fig 2).

If any damage of lesser, above indicate, would result in a more severe condition regarding the compliance with the following damage stability criteria, such damage has to be assumed in the calculations.

Figure 1 : Standard damage case, longitudinal extension (example of damage on the shell and extension of flooding) *(1/7/2011)*

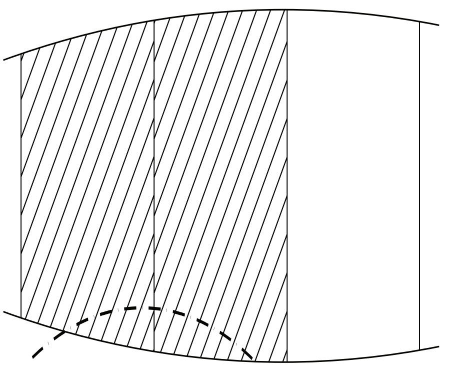
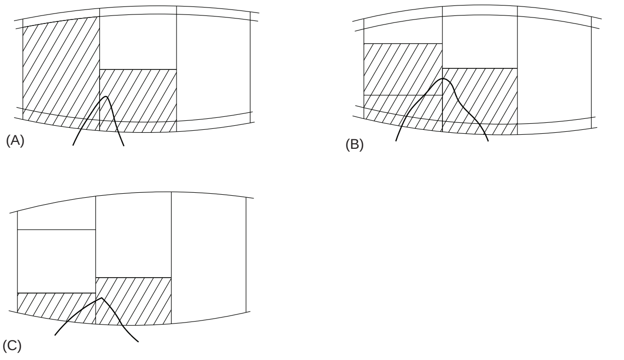


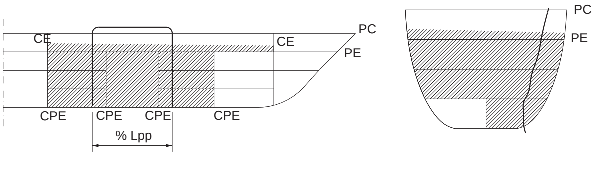
Figure 2 : Standard damage case, transversal extension (example of transversal penetration and flooding extension)



(A) and (B): Flooding of two compartments where the longitudinal bulkhead remains undamaged

(C): Flooding of two compartments where the longitudinal lateral bulkheads remain watertight and may generate a stability condition more unfavourable caused by the heeling

Figure 3 : Standard damage case, vertical extension (example of vertical penetration and flooding extension):



Longitudinal extension of damage, in % of LPP

2.4.3 Permeability

For the purpose of making damage stability calculations the volume and surface permeabilities are to be in general as reported in Tab 1. Other values can be accepted when duly justified. Other values can be accepted when duly justified.

The permeability for cargo spaces intended for the stowage of land vehicles, barges, helicopters and containers is to be derived by calculation in which the land vehicles, barges, helicopters and containers are to be assumed as non-watertight and their permeability taken as 0,65.

In no case is the permeability of cargo spaces in which the goods vehicles and containers are carried to be taken less than 0.60.

Table 1 : Values of permeability

Spaces	Permeability
Diesel engine and auxiliaries	0,85
Steam engines	0,90
Boilers	0,80
Pumps, steering gears and stabilisators	0,90
Mooring chains storage	0,65
Technical activities	0,95
Stores and refrigerated goods	0,80
Intended for liquids	0 or 0,98 **(1)**
Accommodation and military operational areas	0,95
Ammunition storage	0,80 **(2)**
Appropriated for ro-ro cargo	0,90
Voids compartments	0,97
(1) whichever results in the more severe requirements **(2)** when partially loaded 0.95 (see Ch 1, Sec 2, [5.3])	

2.4.4 Free surface effects

For partially filled tanks a free surface effect has to be considered as defined in Ch 2, Sec 2, [2.2.4].

2.4.5 Run-off weights after damage

When a tank is involved in a damage, its content runs-off through the consequent breach. Such content is called run-off weight and shall be taken into account in damage stability calculation.

2.4.6 Equalisation *(1/7/2011)*

The equalisation to take into account in the damage stability calculations, for the purpose of comply with the survival condition stated in [2.4.11], may be accepted in the following conditions:

a) Self acting cross-connection.

b) The system is independent without any power supply

c) The equalisation has to be completed in the time:
   - for D < 4500 t time < 2 min
   - for 4500 t > D < 10000 time < $0,1(D/1000)^2$ min
   - for D > 10000 t time < 10 min

Suitable information concerning the use of cross-flooding fittings is to be supplied to the Master of the ship.

For cross flooding verification, see App 3.

2.4.7 Safety balancing *(1/7/2011)*

The safety balancing to take into account in the damage stability calculations, for the purpose of comply with the safety condition stated in [2.4.12], may be accepted in the following conditions:

a) The system is independent without any power supply

b) The safety balancing has to be completed within 15 minutes.

Suitable information concerning the use of cross-flooding fittings is to be supplied to the Master of the ship.

The means to operate cross-flooding arrangements (such as valves) are to be located above the damage control deck and are to remain operable with an heeling angle not less than 20°.

For cross flooding verification, see App 3.

2.4.8 Residual stability after damage *(1/7/2011)*

The residual stability of the vessel ship at the end of flooding is calculated taking into account of the following:

- Characteristics of the righting arms curves for all the damage cases;
- Relating such curves with the heeling arms curves caused by the wind athwartship.

2.4.9 Characteristics of righting arm curves *(1/1/2017)*

Righting arm curves shall comply with the following requirements:

a) It has to be carried out by the loss of buoyancy method. Such method recognised by IMO (International Maritime Organisation) studies the damage maintaining constant the displacement of the ship (the flooded volume don't take part in buoyancy of the ship.

b) The calculation of the righting arms at several angles shall be calculated at equilibrium of longitudinal moment (changeable trim), corrected for free surface effects.

c) Superstructure and deckhouses can be taken into account up to the angle at which their openings not provided with weathertight closing appliances are flooded.

d) The righting arms curves are extending to the smallest of the following angles:
   1) θ_s (Capsizing angle)
   2) θ_f (Angle at which the first opening result submerged)
   3) 45°.

2.4.10 Stability criteria required for the survival condition *(1/7/2011)*

In all the damage cases and after the equalisation, if present and fully compliant with [2.4.7], the ship shall fulfil the following requirements relevant to the survival condition:

- Provided that particular requirements are present in the contract or in the specification, the ship at the end of flooding shall reach an equilibrium heeling angle not more than 20°.

  $\theta_e \leq 20°$
- Initial metacentric height

  The initial metacentric height value at a null angle has to be calculated.

Particular consideration are necessary if, in such case, such value results negative or too small.

Surely the value of the initial metacentric height at null angle points out the possibility of a lolling.

In such case the equalisation by movement of weights onboard may result dangerous. The analysis shall be take into account actions (change of trim, lowering of centre of gravity, etc.) which allow the reaching of a positive value of the initial metacentric height, and therefore to avoid the lolling.

2.4.11 Stability criteria required for the safety condition *(1/1/2017)*

In all the damage cases, after having granted the survival conditions listed in [2.4.12] and after the safety balancing, if present and fully compliant with [2.4.8], the ship shall fulfil the following requirements relevant to the safety condition:

- Provided that particular requirements are present in the contract or in the specification, the ship at the end of flooding shall reach an equilibrium heeling angle not more than 15°.

  $\theta_e < 15°$

- Initial metacentric height

  The initial metacentric height value at a null angle shall be positive:

  $GM_{corr} > 0$

- Waterline after damage

  At the end of flooding and safety balancing, the trim and equilibrium angle shall be such that the requirements as defined in Ch 1, Sec 2, [3.2.1] are complied with.

  Alternatively, where specified in the regulatory framework (see Pt A, Ch 2, App 1), the above requirements may be waived provided that, in any stage of flooding, the waterline, taking into account sinkage, heel and trim, is below:

  - the lower edge of any opening through which progressive flooding or downflooding may take place. Such openings shall include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, and side scuttles of the non-opening type;
  - any part of the bulkhead deck considered an evacuation route or route for damage control;
  - any controls intended for the operation of watertight doors, equalisation devices, valves on piping or on ventilation ducts intended to maintain the integrity of watertight bulkheads;
  - the emergency source of electrical power.

- Stability reserve (see Fig 4)

  The area A_1, representative of the righting energy has to be higher than the value calculated by the Fig 8 and Fig 9. It represents the results of a statistic research among several ships, and gives the amount of minimum righting energy such that face the heeling energy caused by a moderate sea.

  $A_1 > RSA$

  See Fig 8 and Fig 9.

2.4.12 Comparison between the righting arms and heeling arms curves for severe wind and rolling *(1/7/2011)*

a) Method to evaluate the stability

   The method is the same as defined in Ch 2, Sec 2, [2.3]. Nevertheless the values of rolling and speed of wind to take into account are those represented in Fig 5, Fig 6 and Fig 7 as appropriate.

b) Stability requirements

   - Before the safety balancing of the ship but after the equalization (if present), at the end of flooding, for the contemporary action of severe wind and rolling as reported in item 1), the ship is to maintain positive initial metacentric height, i.e. she will never capsize. The maximum value of the righting arm reduced by that of the heeling arm at the same angle has to be positive.

     $GZ_{Max} - GZ_{Heel} > 0$

   - After the safety balancing of the ship, if present, or at the end of flooding in any case the ship has to have a stability reserve such to make possible her return in the harbour.

     To this purpose the value of the maximum righting arm reduced by that of the heeling arm at the same angle has to be not less than 0,08 m.

     $GZ_{Max} - GZ_{Heel} > 0,08$

     The value of the area A_1 has to be not less than area A_2 (increased of 40%).

     $A_1 > 1,4\ A_2$

     See Fig 4.

     The area A_2 is limited to the value of rolling angle θ_r determined by Fig 7.

     Curve A: righting arms curve at the end of the flooding.

     Curve B: heeling arms curve caused by severe wind and rolling.

Figure 4 : Righting arms curve and heeling arms caused by severe wind and rolling

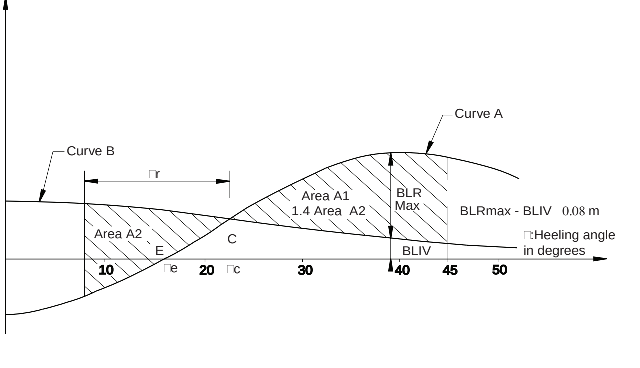


Figure 5 : Determination of speed of the wind to take into account in damage stability calculations for front line ships

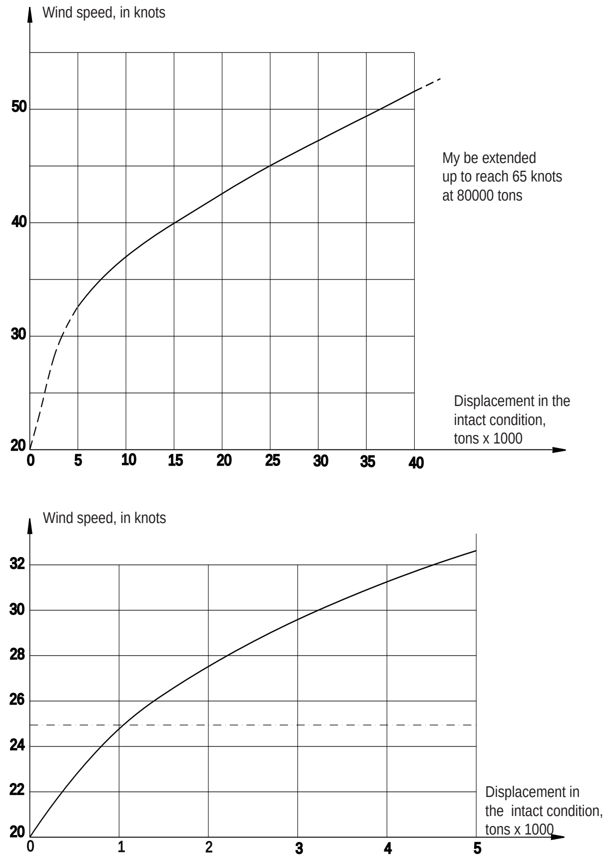


Figure 6 : Determination of speed of the wind to take into account in damage stability calculations for second line and auxiliary ships *(1/7/2011)*

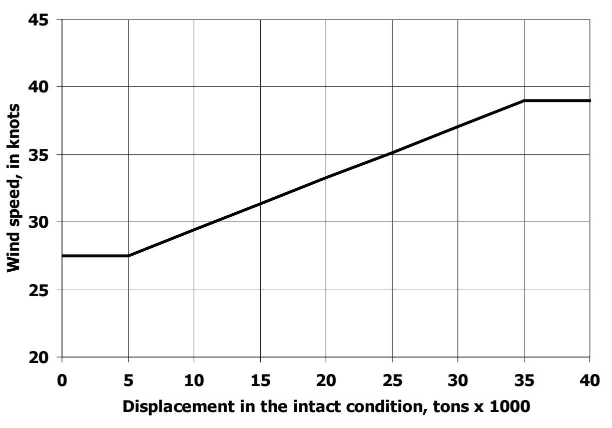


Figure 7 : Rolling angle at the end of the flooding (as a function of the initial displacement)

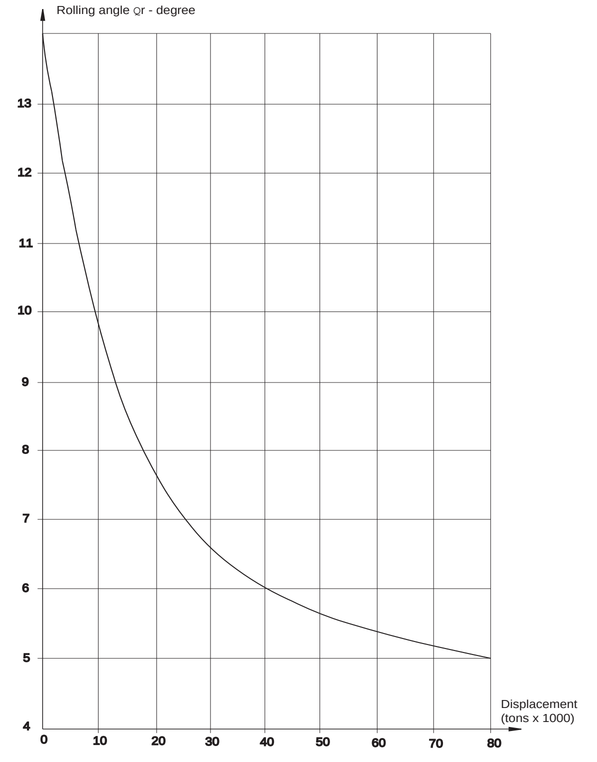


Figure 8 : Values of the areas representative of the stability reserve required at the end of the flooding (as a function of the displacement)

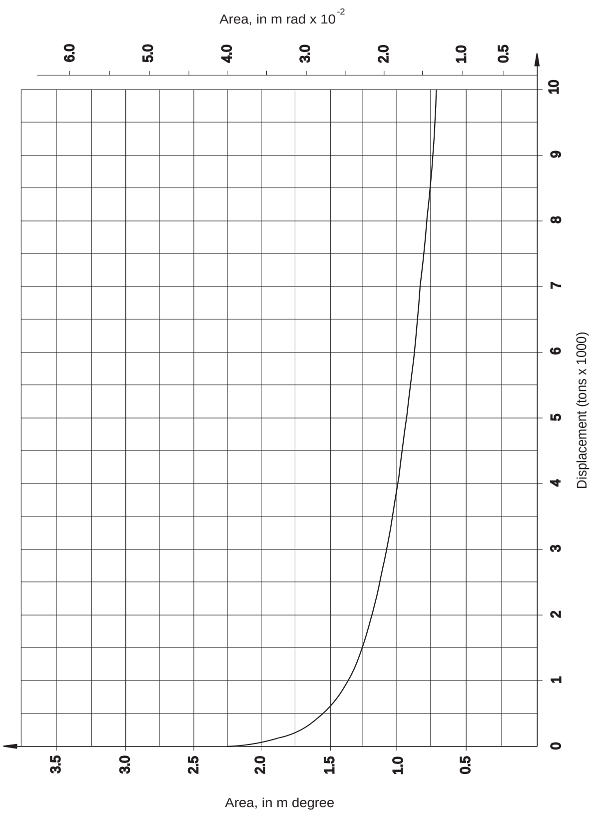
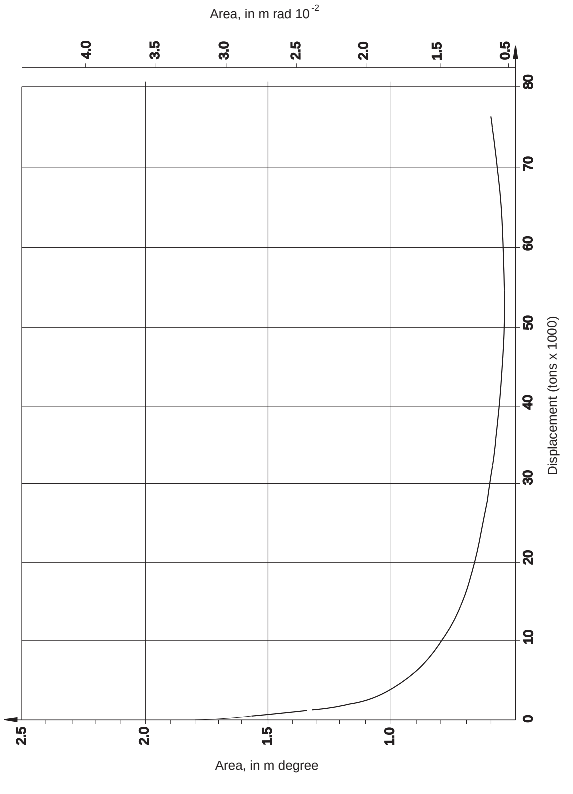


Figure 9 : Values of the areas representative of the stability reserve required at the end of the flooding (as a function of the displacement)



SECTION 4 SEA-KEEPING

1 General

1.1 Introduction

1.1.1 Ship operability

The operability of a military ship is directly linked to the task performance of the crew and the operability of the weapons systems and equipment. The task performance of the crew is influenced by seasickness and fatigue, whereas vessel motions and accelerations limit the operability of weapons systems and equipment.

1.1.2 Operation limits

The operation limits depend on the specific operation the vessel must perform. For normal transit the operation limits ensure that:

- The crew is capable of performing the tasks connected to transit missions.
- Ship motions and accelerations do not affect the equipment needed for transit missions.

Operational limits for other operations like e.g. flight operations and replenishment at sea operations, are defined in Part E under the respective additional class notations.

1.1.3 Verification approach

It is a basic requirement that sea-keeping assessment is performed with the scope of verifying the vessel behaviour in transit missions. This verification is treated in the following.

Verification of a vessels sea-keeping characteristics with respect to the operational limits for particular operations, such as flight and replenishment at sea operations, are considered to be additional class notations and as such subject to requirements in Pt E, Ch 1, Sec 8.

1.1.4 Transit operations (TRAN)

This mission represents the ship's ability to transit as required across the seas. Thus, TRAN models the situation where the ship is moving from one place to another, performing routine shipboard activities.

Survivability in extreme seas is a special subset of the TRAN mission. Two aspects of survivability are of major importance; ultimate stability and ultimate strength. These aspects involve determination of extreme wave induced bending moments. As default the wave induced bending moments are to be taken as described in Ch 5, Sec 2, [3]. However, alternatively a long-term sea-keeping assessment may be carried out in order to determine the extreme bending moment. The principles and criteria to be adopted in a long term sea-keeping assessment are provided in App 6.

The applicability of results of long term sea-keeping assessments as alternative to the requirements in Ch 5, Sec 2, [3] are to be approved by the Society on a case by case basis.

1.2 Hull

1.2.1 General

Limits on the hull are set to prevent structural damage caused by slamming or wetness (water on deck), and to prevent degradation of the ship operability due to propeller emergence.

Wetness and propeller emergence are to be quantified through the vertical motion relative to the free surface, and slamming is to be quantified through the relative vertical velocity.

1.2.2 Wetness index

The wetness index is defined as the number of occurrences of water on deck in an hour. This index is to be based on the relative vertical motion at the bow combined with the freeboard height D_F at the same location.

In relation to TRAN mission the wetness index limits are defined in Tab 2.

1.2.3 Slamming index

The slamming index is defined as the number of times in an hour a keel emergence is followed by a re-entry in water exceeding a certain threshold velocity.

In relation to TRAN mission the slamming index limits are defined in Tab 2.

1.2.4 Propeller emergence

Propeller emergence is defined as the number of times the highest ¼ of the propeller diameter emerges from the sea surface in an hour. This index is to be based on the relative vertical motion at the propeller location combined with the distance from the propeller axis to the calm water sea surface.

In relation to TRAN mission the propeller emergence limits are defined in Tab 2.

1.3 Personnel performance

1.3.1 General

Limits on personnel performance are set to account for crew safety and effectiveness.

The man efficiency is affected by motion induced interruptions and seasickness, which are directly function of the ship motions and accelerations at the working location.

1.3.2 Motion induced interruption (MII)

A motion induced interruption (MII) is an incident where ship motions cause a person to slide or lose balance, resulting in stumble. Motion induced interruptions does not only represent a danger to the crew, but also prevents the crew from carrying out their tasks.

In relation to TRAN mission the MII limits are defined in Tab 3.

As an alternative to the MII limits, the Root Mean Square (RMS) amplitude value of the ship motions can be used to specify limits. The ship motions that cause MII are roll and pitch.

In relation to TRAN mission the motion RMS limits are defined in Tab 4.

1.3.3 Seasickness

The seasickness corresponds to the man sickness induced by the ship motions.

On a perfectly rested man, the seasickness has a direct influence on his capacity to ensure the given tasks.

Seasickness is best measured in terms of Motion Sickness Incidence (MSI), where MSI is the percentage of the crew who vomit after a given time of exposure to accelerations. MSI is therefore function of ship accelerations (amplitude and frequency) and exposure time.

In relation to TRAN mission the MSI limits are defined in Tab 3.

As an alternative to the MSI the Root Mean Square (RMS) amplitude value of the acceleration can be applied to measure the seasickness. This approach does not take the frequency or the exposure time into account, and thus depends only on the acceleration amplitudes.

In relation to TRAN mission the acceleration RMS limits are defined in Tab 4.

1.4 Assessment procedure

1.4.1 Parameters

The parameters to be considered for the assessment of the sea-keeping are defined in [2]

1.4.2 Evaluation *(1/7/2011)*

The values of the ship sea-keeping parameters are to be assessed by means of computer calculationswith validated software. In case of use of novel software not adequately supported by justification data or upon specific request of the Society, small-scale model tests in a model basin are to be used to validate the calculations.

The computer calculations have to be performed as described in App 6, and the following documentation must be provided:

- Justification of the validity of the used software or model test results that verifies calculated results, as applicable.
- Parameters to be calculated
- Computation input data
- Computation results.

Concerning model tests, if applicable, the following documentation must be provided:

- Parameters to be measured
- Detailed test program
- Analysis procedure of measured data
- Sea- and ship loading-condition during the tests
- Test results and their analysis.

1.5 Environmental conditions

1.5.1 Sea state

Sea state is an expression used to categorise wave conditions and normally a sea state comprises a significant wave height Hs and a wave period.

The environmental conditions are to be described by specifying a sea state according to Tab 1.

Whenever computer calculations or model scale tests are used, i.e. when the environmental conditions are selectable, the sea states used for the verification of the criteria in [3.2] should be defined as described in [1.5.2] and [1.5.3].

Table 1 : Sea states

Sea state	Significant wave height range, in m	Zero up-crossing wave period range, in sec
0-1	0-01	-
2	0,1-0,5	2,0-9,0
3	0,5-1,25	2,5-10,5
4	1,25-2,5	3,0-11,5
5	2,5-4,0	3,5-12,0
6	4,0-6,0	4,0-12,5
7	6,0-9,0	5,0-13,0
8	9,0-14,0	6,0-13,5
>8	>14,0	>13,0

1.5.2 Wave height

Generally, the references to the wave height are to be taken as the significant wave height Hs, i.e. the average of the 1/3 largest wave heights in a sea state.

The description of sea states shown in Tab 1 defines the significant wave height as ranges, not absolute values. For this reason sea states must be referred to not just by their number, but also whether it is a low, mid or high sea state. A low sea state 6 has Hs = 4,0 m, mid sea state 6 has Hs = 5,0 m and high sea state 6 has Hs = 6,0 m.

The wave height to be considered for the verifications should be the largest significant wave height relative to the specified sea state; if a mid sea state 6 is specified, Hs should be taken as 5 m, if only sea state 6 is specified, Hs should be taken equal to 6 m.

1.5.3 Wave period

Generally, references to the wave period are to be taken as the zero up-crossing wave period T_Z, i.e. the average time interval between upward crossings of the mean value.

The description of sea states in Tab 1 defines the limits $T_{Z,MIN}$ and $T_{Z,MAX}$ of the wave period.

As a minimum requirement, the verifications should be carried out for at least four different wave periods. The wave periods to be considered are defined based on the ship length L. However, they are not to be taken outside the range of wave periods for the considered sea state, defined in Tab 1.

-T_{Z1}=$T_{Z,MIN}$, according to Pt E, Ch 1, Sec 8, Tab 1.

$$-T_{Z2} = 0,68\sqrt{L}$$

$$-T_{Z3} = 0,8\sqrt{L}$$

$$-T_{Z4} = 0,92\sqrt{L}$$

1.5.4 Ship speed *(1/1/2025)*

Unless otherwise specified in the Regulatory Framework, the ship speed to be considered for the sea-keeping calculations should be taken as the cruise speed.

1.6 Requirements to be complied with

1.6.1 The requirements of sections [2] and [3] below are equivalent to the requirements in the NATO standard STANAG 4154 Ed.3, except for the MSI and MII criteria in [3.3.1].

2 Hull

2.1 General

2.1.1 Scope

The scope of verifying the hull is to ensure that the ship motions do not become so severe that slamming, water on deck and propeller emergences can damage the hull structure or machinery, or they prevent the vessel from transiting in weather conditions where the ship is expected to carry out its mission.

2.1.2 Requirements *(1/7/2011)*

The requirements for verifying that the vessel is able to transit is that the parameters evaluated in the limiting sea state do not exceed the criteria defined in [2.3].

The limiting sea states in TRAN mission, unless otherwise agreed with the Society, are to be taken as:

- Frontline ships: High Sea State 5
- Secondline ships: High Sea State 4
- Auxiliary ships: High Sea State 3.

The above sea states are defined in Tab 1.

2.2 Parameters

2.2.1 Wetness index

The wetness index is defined as the number of occurrences of water on deck in an hour. This index is to be based on the variance ($m_{0,M}$) of the relative vertical motion at the bow combined with the freeboard height D_F at the same location:

$$WI = N_Z F(D_F)$$

where:

$$F(D_F) = \exp\left(-\left(\frac{D_F}{\sqrt{2m_{0,M}}}\right)^2\right)$$

$$N_Z = \frac{3600}{2\pi}\sqrt{\frac{m_{2,M}}{m_{0,M}}}$$

$m_{0,M}$: zero order spectral moment of relative vertical motion response

$m_{2,M}$: second order spectral moment of relative vertical motion response

2.2.2 Slamming index

The slamming index is defined as the number of times in an hour a keel emergence is followed by a re-entry in water that exceeds a certain threshold velocity:

$$SI = N_Z F(V_{TH}) F(T_{SL})$$

where $F(V_{TH})$ is the probability of exceeding the threshold velocity and $F(T_{SL})$ is the probability of keel emergence; :

$$F(V_{TH}) = \exp\left(-\left(\frac{V_{TH}}{\sqrt{2m_{0,V}}}\right)^2\right)$$

$$F(T_{SL}) = \exp\left(-\left(\frac{T_{SL}}{\sqrt{2m_{0,M}}}\right)^2\right)$$

$$N_Z = \frac{3600}{2\pi}\sqrt{\frac{m_{2,M}}{m_{0,M}}}$$

$m_{0,V}$: zero order spectral moment of relative vertical velocity response

$m_{0,M}$: zero order spectral moment of relative vertical motion response

$m_{2,M}$: second order spectral moment of relative vertical motion response

The location of the slamming assessment is to be at the keel at 3/20 L behind the fore perpendicular.

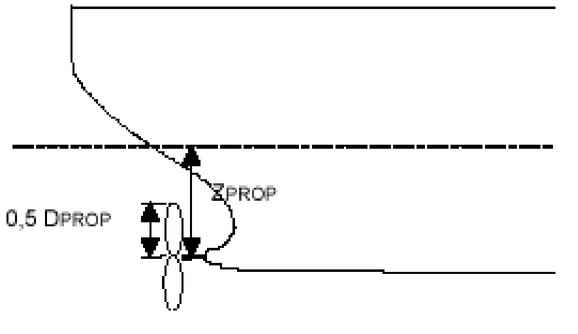
The vertical threshold velocity is based on the ship length, and defined as:

$$V_{TH} = 3,66\sqrt{\frac{L}{158,5}}, \text{ in m/s}$$

2.2.3 Propeller emergence

Propeller emergence is defined as the number of times the highest ¼ of the propeller diameter (DPROP) emerges from the sea surface in an hour. This index is to be based on the variance (m0,M) of the relative vertical motion at the propeller location combined with the distance from the propeller axis to the calm water sea surface (ZPROP):

Figure 1



According to above definitions propeller emergence occurs when the relative motion exceeds Z_{PE} defined as:

$$Z_{PE} = Z_{PROP} - \frac{1}{4}D_{PROP}$$

The number of propeller emergences in an hour can now be determined as:

$$PE = N_Z F(Z_{PE})$$

where:

$$F(Z_{PE}) = \exp\left(-\left(\frac{Z_{PE}}{\sqrt{2m_{0,M}}}\right)^2\right)$$

$$N_Z = \frac{3600}{2\pi}\sqrt{\frac{m_{2,M}}{m_{0,M}}}$$

$m_{0,M}$: zero order spectral moment of relative vertical motion response

$m_{2,M}$: second order spectral moment of relative vertical motion response

2.3 Criteria

2.3.1 The recommended criteria that ensure that slamming, wetness and propeller emergence events do not become excessive are given in Tab 2.

Table 2 : Hull criteria limits

MONOHULL		
Parameter	Limit	Location
Wetness index (WI)	30/hr	Bow(worst location)
Slamming index (SI)	20/hr	Keel, 3/20 L aft of FP
Propeller emergence (PE)	90/hr	1/4 propeller diameter
AIRCRAFT CARRIER **(1)**		
Slamming (SI)	20/hr	Sponson
(1) In addition to monohull criteria limits		

3 Personnel behaviour

3.1 General

3.1.1 Scope

The scope of verifying the personnel behaviour is to ensure that the ship motions and accelerations do not become so severe that they prevent the crew from carrying out their tasks in weather conditions where the ship is expected to carry out its mission.

3.1.2 Requirements *(1/7/2011)*

The requirements for certifying that the crew is able to carry out their tasks in TRAN mission is that the parameters evaluated in the limiting sea state do not exceed the criteria defined in [3.3].

On a case by case basis the Society can accept that e.g. calculations taking into consideration the effect of active motion damping systems (anti-roll fins, T-foils etc.) or model test results are utilised in order to demonstrate compliance with these criteria.

The limiting sea states in TRAN mission, unless otherwise agreed with the Society, are to be taken as:

- Frontline ships: High Sea State 5
- Secondline ships: High Sea State 4
- Auxiliary ships: High Sea State 3

The above sea states are defined in Tab 1.

3.2 Parameters

3.2.1 Motion sickness incidence (MSI)

A simple and empirical model to relate motion sickness and vertical oscillations is given as:

$$MSI(\%) = 100*\left(0,5 + \operatorname{erf}\left(\frac{\log_{10}(a_v) - \mu_{MSI}}{0,4}\right)\right)$$

where:

$$\mu_{MSI} = -0,819 + 2,32(\log_{10}(\omega_e))^2$$

$$a_V = 0,7898 \cdot RMS_{AZ}\sqrt{\frac{T}{2}}$$

$$\omega_e = 2\pi / T_{Z,e}$$

In the formulas above T is the exposure time in hrs, a_V represents the vertical acceleration (in units of g) averaged over half a motion cycle, where RMS_{AZ} is the root mean square value, ω_e is the (encounter) frequency of the vertical oscillations (in units of rad/s) and $T_{Z,e}$ is the average zero up-crossing period of the vertical accelerations experienced by the ship in irregular waves, defined as:

$$T_{Z,e} = \frac{2\pi}{\sqrt{\frac{m_{2,AZ}}{m_{0,AZ}}}}$$

$m_{0,AZ}$: zero order spectral moment of vertical acceleration

$m_{2,AZ}$: second order spectral moment of vertical acceleration

If agreed with the Society other models for determining the MSI may be applied.

3.2.2 Motion induced interruption (MII)

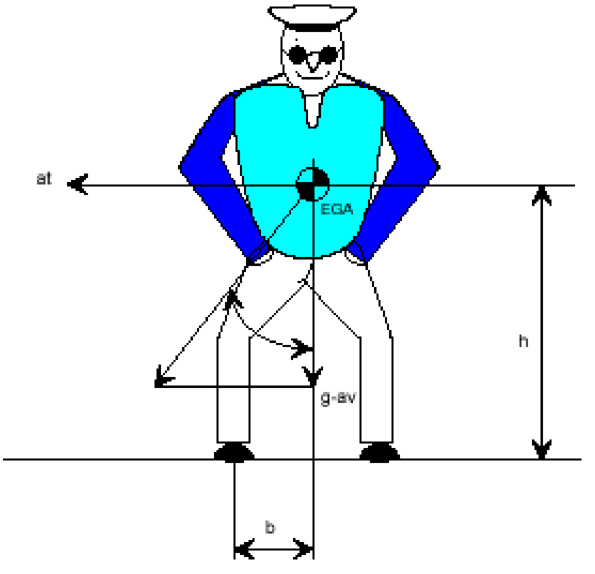
In order to determine the MII index, one has to evaluate the so-called Generalised Lateral Force Estimator for tipping port or starboard according to the definition below:

$$GLFE_p = \frac{1}{3}h\ddot{\phi} - a_T - g\phi - \frac{b}{h}a_V$$

$$GLFE_s = \frac{1}{3}h\ddot{\phi} - a_T - g\phi + \frac{b}{h}a_V$$

where b and h are defined in Fig 2.

Figure 2 : Definitions for generalised lateral force estimator



The ratio b/h is called lateral tipping coefficient and a representative value of 0,25, with h being 1,20 m, can be assumed based on typical human dimensions.

The formula above must be interpreted as a linear combination of the transfer functions (in-phase, pedex C, and out-of-phase, pedex S, components) of roll motion ϕ, roll acceleration $\ddot{\phi}$, transverse acceleration a_T and vertical acceleration a_V, which can be safely considered as a standard output from frequency-domain codes.

By definition of generalised lateral force estimator, a tipping event occurs whenever the estimator exceeds the threshold level (b/h)g . In order to evaluate this occurrence frequency one has to rely upon standard spectral theory, which is routinely incorporated into frequency-domain sea-keeping codes.

The first step is to determine the in/out-of-phase components of the estimator, $GLE_{p,sC,S}$ and consequently its amplitude:

$$GLE_{p,s_a} = \sqrt{(GLE_{p,s_C})^2 + (GLE_{p,s_S})^2}$$

The second step is the evaluation of its zero'th and second order spectral moments:

$$m_{0;p,s} = \int_{\omega_{min}}^{\omega_{max}} GLE^2_{p,s_a} \cdot S(\omega)d\omega$$

$$m_{2;p,s} = \int_{\omega_{min}}^{\omega_{max}} \left|\omega - \frac{\omega^2 V}{g}\cos(\psi)\right|^2 \cdot GLE^2_{p,s_a} \cdot S(\omega)d\omega$$

where $S(\omega)$ is the wave spectrum of the sea state, ω is the wave frequency in rad/s, V is the ship speed in m/s, ψ is the heading angle and g is the gravity acceleration in m/s^2.

The motion induced interruptions due to lateral tipping port/starboard $MII_{p,s}$ (in units of tipping events per minute) can thence be calculated as:

$$MII_{p,s} = \frac{60}{2\pi}\sqrt{\frac{m_{2;p,s}}{m_{0;p,s}}}\exp\left(-\frac{a^2}{2m_{0;p,s}}\right)$$

having posed a = (b/h)g . Finally, the MII can be determined as:

$$MII = MII_p + MII_s$$

3.3 Criteria

3.3.1 Recommended criteria

The recommended criterion that ensures that the crew can carry out their tasks in a safe and sufficiently effective manner is given in Tab 3.

Table 3 : Recommended personnel criteria limits

Parameter	Limit	Location
Motion Sickness incidence (MSI)	35% of crew in 2 hrs	Task location
Motion Induced Interruption (MII)	3/min	Task location

3.3.2 Default criteria

The default criteria that ensures that the crew can carry out their tasks in a safe and sufficiently effective manner is given in Tab 4.

Table 4 : Default personnel criteria limits

Parameter	Limit	Location
Roll	4°	
Pitch	1,5°	
Vertical acceleration	0,2 g	Bridge
Lateral acceleration	0,1 g	Bridge
Note 1: all limits given as RMS amplitude values		

APPENDIX 1 INCLINING TEST AND LIGHTWEIGHT CHECK

1 Inclining test and lightweight check

1.1 General

1.1.1 General conditions of the ship *(1/1/2017)*

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 practicable, 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 to be not 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 *(1/1/2017)*

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 *(1/1/2017)*

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 having 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 a partial shifting, to each side of upright, of at least 10 cm. To ensure that recordings from individual instruments are kept separated, it is suggested that the pendulums are physically located as far apart as practicable.

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 *(1/1/2017)*

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 Fig 1.

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.

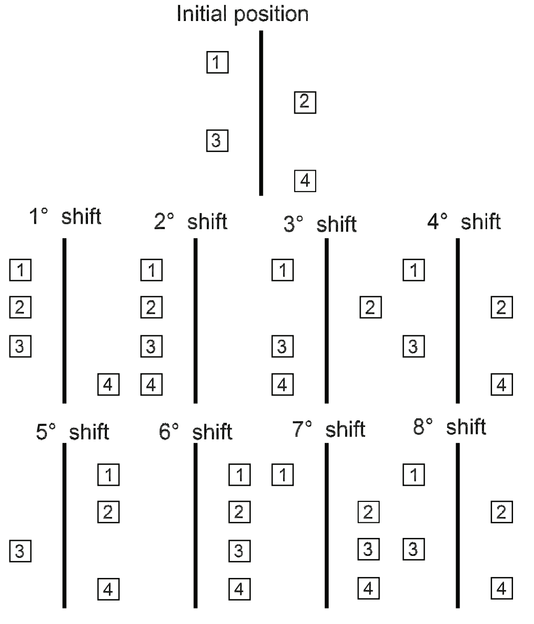
After each weight movement, the distance the weight was moved (centre to centre) is to be measured and the heeling moment calculated by multiplying the distance by the amount of weight moved. The tangent is calculated for each pendulum by dividing the deflection by the length of the pendulum. The resultant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

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 : Weight shift procedure



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 6 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 : Graph of resultant tangents *(1/1/2017)*

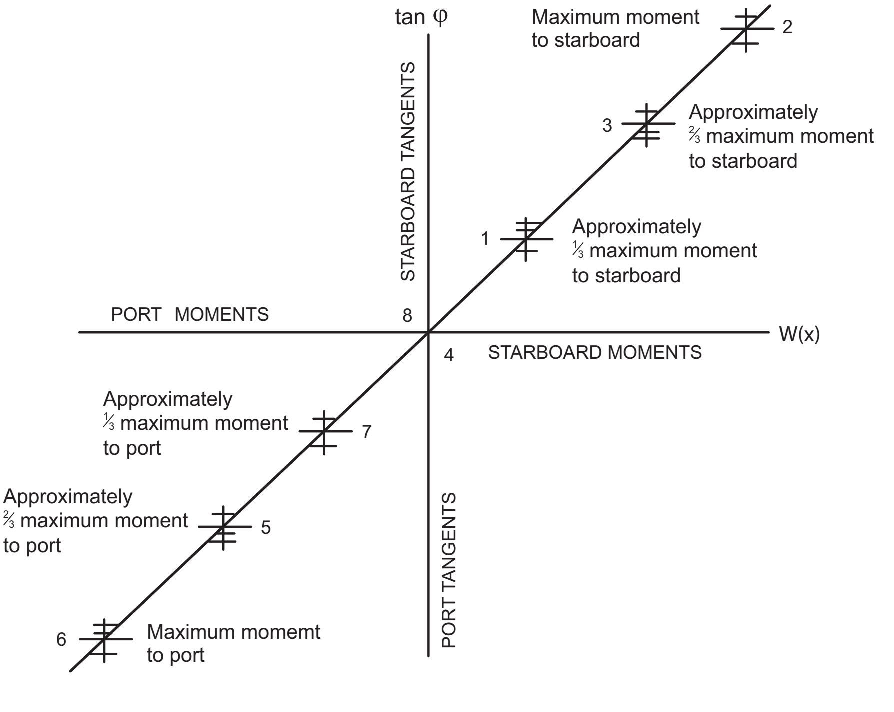


Figure 3 : Excessive free liquids (re-check all tanks and voids and pump out as necessary; re-do all weight movements and re-check freeboard and draught readings *(1/1/2017)*

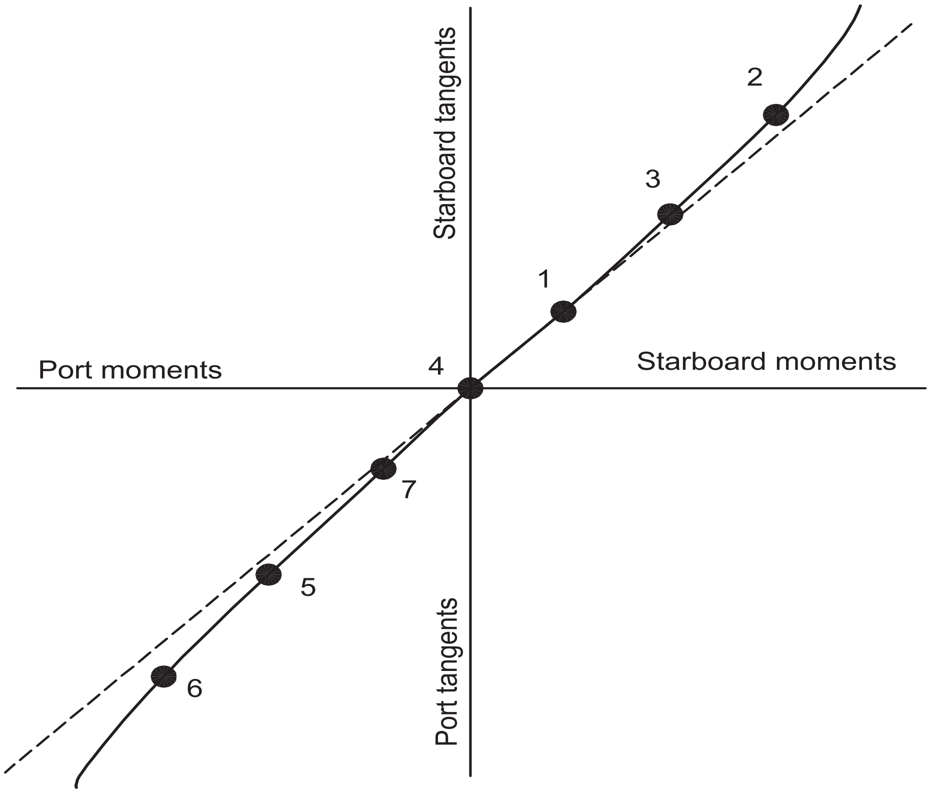


Figure 4 : Ship touching bottom or restrained by mooring lines (take water soundings and check lines: re-do weight movements 2 and 3) *(1/1/2017)*

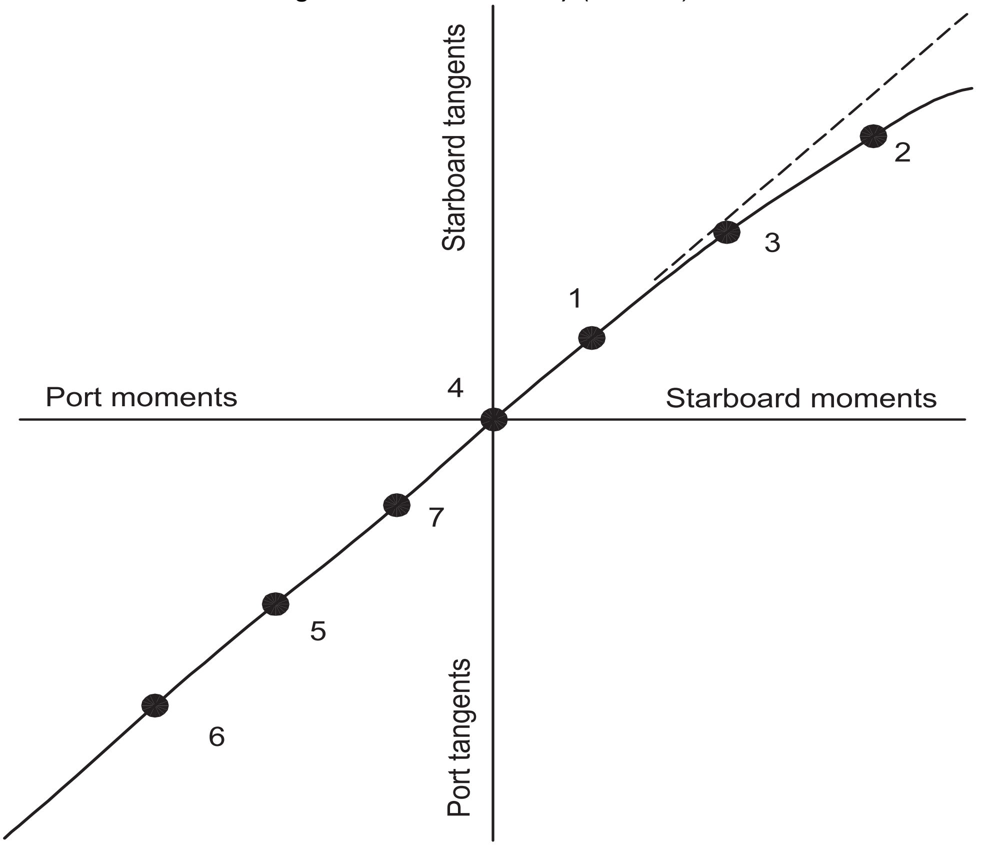


Figure 5 : Steady wind from port side came up after initial zero point taken (plot acceptable) *(1/1/2017)*

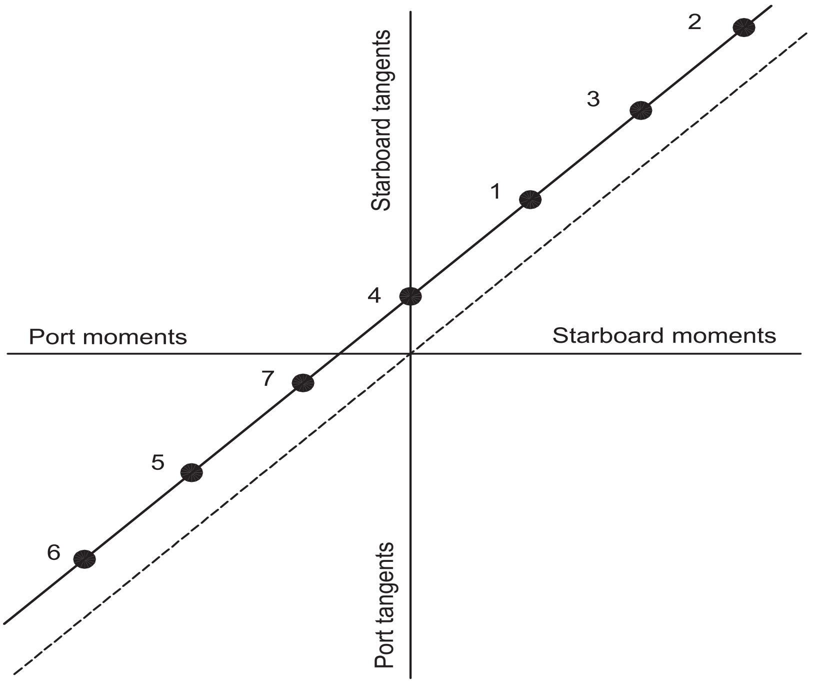
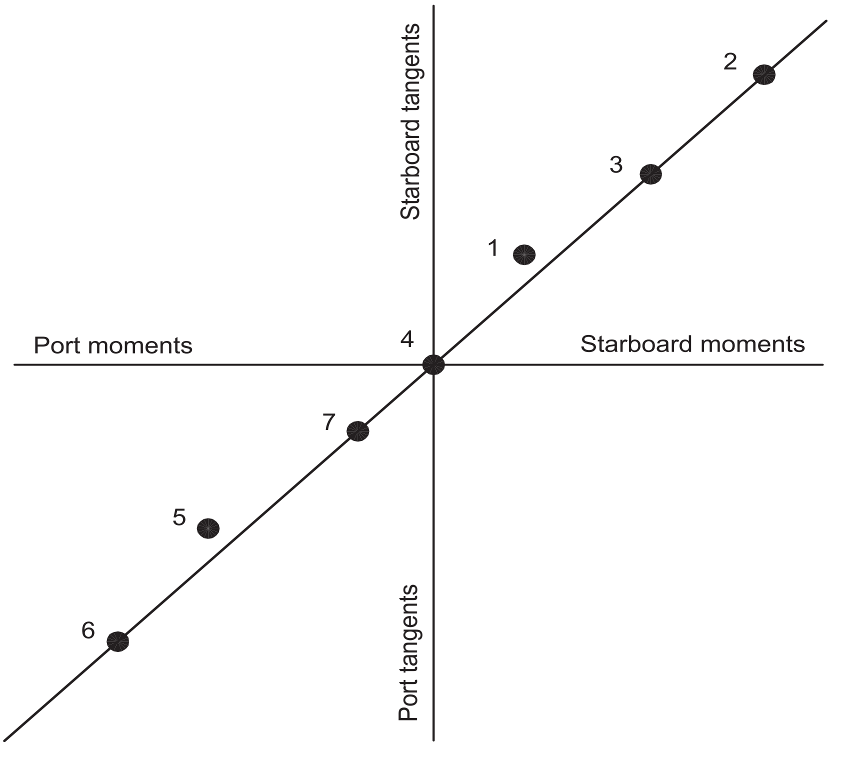


Figure 6 : Gusty wind from port side (re-do weight movements 1 and 5) *(1/1/2017)*



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 *(1/1/2017)*

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 moulded dimensions
  - the draught corresponding to the assigned operational loaded ship Ch 1, Sec 2, [5.3], the draught corresponding to the assigned full loaded ship Ch 1, Sec 2, [5.2]).
  - 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, 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 mentioned for project verification in Ch 1, Sec 2, [5.2], Ch 1, Sec 2, [5.3] 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 as well as possible additional criteria specified in Part D 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 [1.2].
- damage stability results (total displacement and its maximum permissible centre of gravity height, draughts at perpendiculars, GM, GM corrected for free surfaces effect, GZ values and curve, criteria as indicated in Sec 3 as well as possible additional criteria specified in Part D 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 [1.2].
- 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, maximum KG or minimum GM curve or table which can be used to determine compliance with the applicable intact and damage stability criteria) when applicable
- information about openings (location, tightness, means of closure), pipes or other progressive flooding sources
- information concerning the use of any special cross-flooding fittings with descriptions of damage conditions which may require cross-flooding, when applicable
- any other necessary guidance for the safe operation of the ship
- a table of contents and index for each booklet.

1.2 Stability curve calculation

1.2.1 General *(1/1/2017)*

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.

1.2.2 Superstructures, deckhouses, etc. which may be taken into account *(1/1/2017)*

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

Additional tiers of 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 main deck may be taken into account, provided that they comply with the conditions for enclosed superstructures laid down in Ch 1, Sec 2.

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 8, 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 8, Sec 7, [7.3].

Deckhouses on decks above the main 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 spaces 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.

1.2.3 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.

APPENDIX 3 CALCULATION METHOD FOR CROSS-FLOODING ARRANGEMENTS

1 Calculation method for cross-flooding arrangements

1.1 Cross-flooding area

1.1.1 Cross-flooding area calculation

The cross-flooding area S, in m², can be calculated from the following formula:

$$S = \frac{2W}{tF(\sqrt{2gH_o} + \sqrt{2gH_F})}$$

where:

W : Volume, in m³, of water entering the equalising compartments during the period considered

t : Time, in s, necessary to complete the equalisation

F : Factor, to be taken equal to:

$$F = \frac{1}{\sqrt{1 + \sum k}}$$

In general, a value of F equal to 0,65 may be used. Anyway, for particular shape of pipes, appropriate values of k are to be used in the above formula.

k : Dimensionless factor of reduction of speed through the duct, being a function of bends, valves, etc., in the cross-flooding system, to be obtained from [1.1.2], as the case may be

g : Gravity acceleration, in m/s²:

$g = 9,81$ m/s²,

H_o : Initial head of water, in m,

H_F : Final head of water after cross-flooding, in m.

1.1.2 Factor of reduction k

The factor of reduction is to be calculated depending on the following cases :

- Case 1 : 90° circular bend
- Case 2 : radius bend R/D = 2
- Case 3 : mitre bend
- Case 4 : 90° double mitre bend
- Case 5 : pipe inlet
- Case 6 : pipe outlet
- Case 7 : non-return valve
- Case 8 : pipe friction losses
- Case 9 : gate valve
- Case 10 : butterfly valve
- Case 11 : disc valve

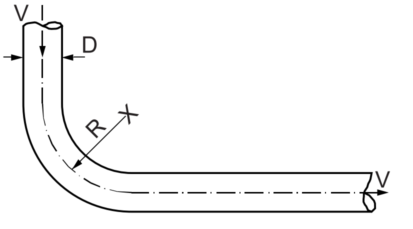
Case 1 : 90° CIRCULAR BEND (see Fig 1)

The factor k is defined in Tab 1.

Table 1 : Values of factor k

R/D	2	3	4	5	6	7
k	.30	.26	.23	.20	.18	.17

Figure 1 : 90°CIRCULAR BEND



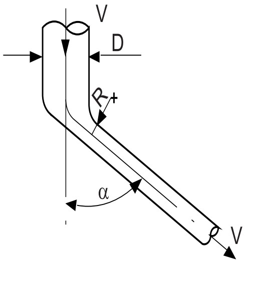
Case 2 : RADIUS BEND R/D = 2 (see Fig 2)

The factor k is defined in Tab 1.

Table 2 : Values of factor k

α°	15	30	45	60	75	90
k	.06	.12	.18	.24	.27	.30

Figure 2 : RADIUS BEND R/D = 2



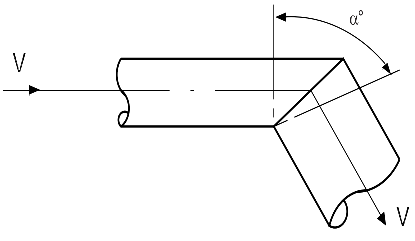
Case 3 : MITRE BEND (see Fig 3)

The factor k is defined in Tab 2.

Table 3 : Values of factor k

α°	5	15	30	45	60	90
k	.02	.06	.17	.32	.68	1.26

Figure 3 : MITRE BEND



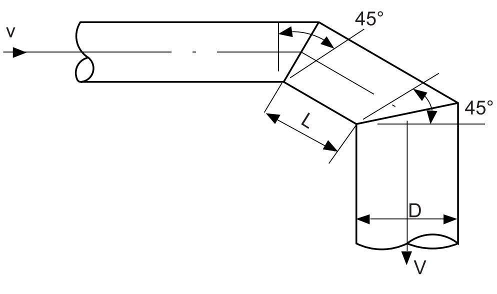
Case 4 : 90°DOUBLE MITRE BEND (see Fig 4)

The factor k is defined in Tab 4.

Table 4 : Values of factor k

L/D	1	2	3	4	5	6
k	.41	.40	.43	.46	.46	.44

Figure 4 : 90° DOUBLE MITRE BEND



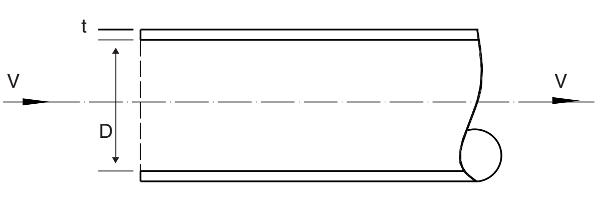
Case 5 : PIPE INLET (see Fig 5)

The factor k is defined in Tab 4.

Table 5 : Values of factor k

t/D	.01	.02	.03	.04	.05	>.05
k	.83	.68	.53	.46	.44	.43

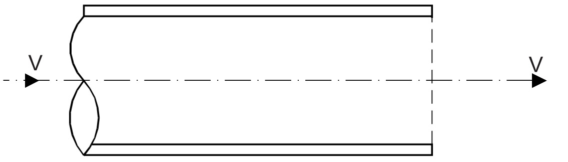
Figure 5 : PIPE INLET



Case 6 : PIPE OUTLET (see Fig 6)

k = 1.0

Figure 6 : PIPE OUTLET

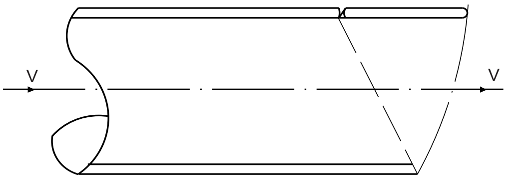


Case 7 : NON-RETURN VALVE (see Fig 7)

k = 0.5

The value of k actually increases with decrease in Froude number, particularly below speeds of 2m/sec.

Figure 7 : NON-RETURN VALVE



Case 8 : PIPE FRICTION LOSSES

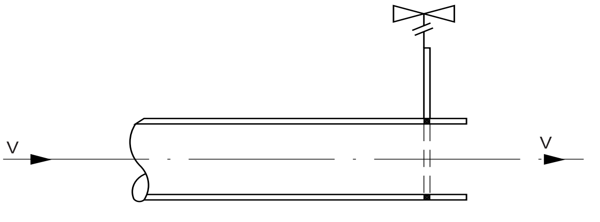
k = 0.02/D per unit length

The coefficient above is a mean value and does in fact vary as Reynold's number (i.e. varies with V for constant D and v) as well as with relative roughness.

Case 9 : GATE VALVE (see Fig 8)

k = 0.3

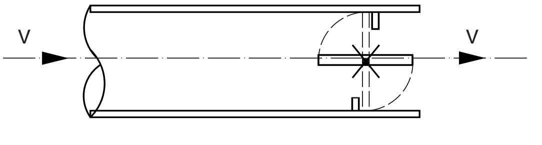
Figure 8 : GATE VALVE



Case 10 : BUTTERFLY VALVE (see Fig 9)

k = 0.8

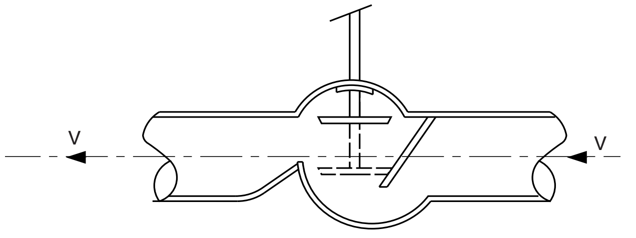
Figure 9 : BUTTERFLY VALVE



Case 11 : DISC VALVE (see Fig 10)

k = 6.0

Figure 10 : DISC VALVE



1.1.3 Overflows

In general, the area of overflows relevant to the connected compartments is to be not less than S/10, where S is defined in [1.1.1].

1.2 Interpretation of the requirements relevant to final stage of flooding

1.2.1 When major progressive flooding occurs, that is when it causes a rapid reduction in the righting lever of 0,04 m or more, the righting lever curve is to be considered as terminated at the angle the progressive flooding occurs and the range and the area referred to in Sec 3, [2.4.6] are to be measured to that angle, as shown in Fig 11.

1.2.2 In the case where the progressive flooding is of limited nature that does not continue unabated and causes an acceptably slow reduction in righting lever of less than 0,04 m, the remainder of the curve is to be partially truncated by assuming that the progressively flooded space is so flooded from the beginning, as shown in Fig 12.

Figure 11 : Major progressive flooding

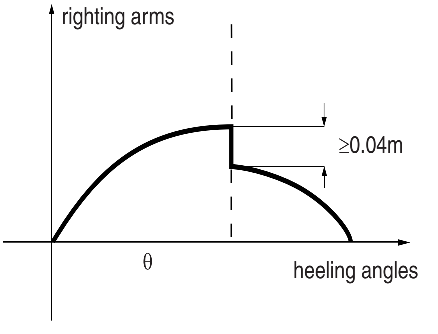
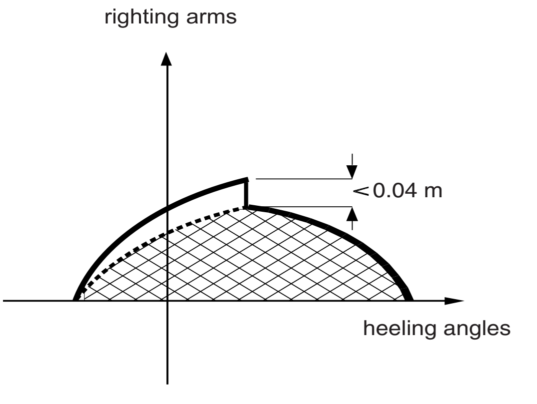


Figure 12 : Progressive flooding of limited nature



APPENDIX 4 BUOYANCY RESERVE - “V” LINE METHOD

1 Buoyancy reserve

1.1 Purpose

1.1.1 *(1/7/2011)*

This method allows to define, in a simplified and conservative way, the zones that may be interested by progressive flooding in damage conditions taking into account the dynamic effect of waves and ships motion.

The purpose of the "V" Line calculation is to determine, at a preliminary stage of the design, the part of bulkheads above the bulkhead deck or, when fitted, above the watertight deck, where unprotected openings may be fitted without compromising the stability characteristics.

The "V" lines calculation, is to be considered as an instrument for the designer whilst the final verification of damage stability and required protection for openings in watertight/weathertight boundaries is to be carried out in accordance with Sec 3.

1.1.2 Method *(1/7/2011)*

The longitudinal envelope of the waterlines at the end of each symmetrical flooding for all examined loading conditions is to be taken into account.

In each transversal section interested by such envelope, proceed as follows.

a) An heeling angle equal to 45° is to be considered (maximum angle for the calculation of area A1 of the righting arm curves; see Sec 3, [2.4]).

b) An elevation of the consequent level of 1,25 m is added to the waterline to consider the movement of the water inside the ship.

1.1.3 Interpretation of the obtained “V” Line *(1/7/2011)*

The "V" Line identifies, in each transversal sections two different zones above the bulkhead deck:

a) **Zone inside “V” Line**, where it's possible to cross the auxiliary transversal bulkheads and the main deck without particular requirements relevant to the restoring of watertight integrity.

b) **Zone outside “V” Line**, where each crossing and/or opening has to be provided with suitable system of watertight or weathertight (as applicable; see Sec 3, [2.2.2]) closure.

APPENDIX 5 EVALUATION OF THE HEELING MOMENT DUE TO ATHWART WIND

1 Evaluation of the heeling moment due to athwart wind

1.1 Intact stability

1.1.1 Inclining moment caused by wind, is carried out with the following formula:

$$IM = \frac{0,0195 \cdot V^2 \cdot A \cdot h \cdot \cos^2 \theta}{1000}$$

See Fig 2.

IM : inclining moment (t·m)

V : wind speed (knots)

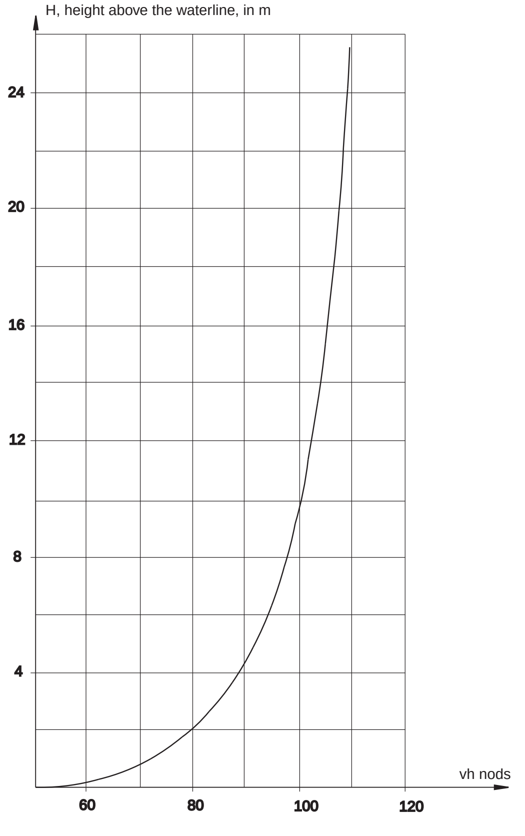
h : vertical distance between the windage centre surface and driftage centre surface which may be considered at middle of draught (m)

A : area of windage surface, above the waterline (m^2)

θ : transversal heeling angle (degrees)

1.1.2 To obtain the value of the inclining arm the results of the obtained value of [1.1.1] is to be divided by displacement of the vessel at the loading condition in question.

Figure 1 : Speed of the wind as a function the elevation up the waterline



1.1.3 To define the heeling moment curve caused by wind together with the result of the formula in [1.1.1], the Fig 1 is to be utilised. In that the changing of the wind speed as a function of the elevation up the waterline for a theoretical speed of 100 Knots at 10 m is represented. The value of the wind on the windage area has to be corrected by the ratio with such curve.

c) To the purpose to facilitate the task, the value reported in Tab 1 may be used, they give starting from the formula as in [1.1.1] the values of the inclining moment take into account of the gradient due to the change of the elevation up the waterline.

1.1.4 Calculation procedure

a) The windage area has to be divided into strips of height 2 m starting from the considered waterline

b) Calculate the surface in m^2 of all the strips.

c) Evalute the vertical position of the centre of driftage area (approximatively corresponding to half draught) and, for each strip, assign to it the corresponding moment value as indicated in Tab 1.

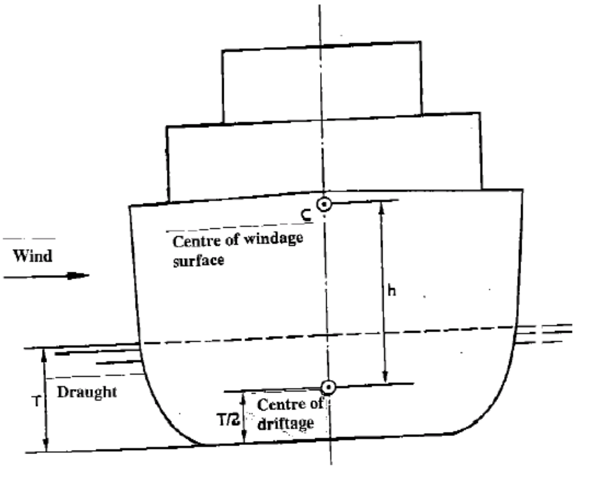
d) Multiply the value obtained in b) by that obtained in c)

e) Add all moments so obtained to have a moment corresponding to a theoretical speed of the wind of 100 Knots

f) For speed of the wind different from 100 Knots, multiply the value obtained in e) with the following formula:

$$\left(\frac{V}{100}\right)^2$$

Figure 2 : Example showing the elements used in carrying out the heeling arms caused by wind



1.2 Damage stability

1.2.1 The same approach as in [1.1] is to be followed taking into account of:

h: vertical distance between the windage centre surface and driftage centre surface which may be considered at middle of draught (m) in the final equilibrium condition of the conclusion of damages.

Table 1 : Inclining moment (t· m) for m² for a theoretical speed of the wind of 100 knots

Height above waterline (in m)	Ship centre of lateral resistance below waterline (in m)											
	0,25	**0,50**	**0,75**	**1,00**	**1,25**	**1,50**	**1,75**	**2,00**	**2,25**	**2,50**	**2,75**	**3,00**
0-2	0,13	0,16	0,19	0,21	0,24	0,27	0,29	0,32	0,35	0,37	0,40	0,43
2-4	0,45	0,49	0,52	0,56	0,59	0,63	0,66	0,70	0,73	0,77	0,80	0,84
4-6	0,87	0,91	0,95	0,99	1,03	1,08	1,12	1,16	1,20	1,24	1,28	1,32
6-8	1,31	1,36	1,40	1,45	1,49	1,54	1,58	1,63	1,67	1,72	1,76	1,81
8-10	1,76	1,81	1,86	1,90	1,95	2,00	2,05	2,09	1,14	2,19	2,24	2,28
10-12	2,23	2,28	2,33	2,38	2,43	2,48	2,53	2,58	2,63	2,67	2,72	2,77
12-14	2,72	2,77	2,82	2,87	2,93	2,98	3,03	3,08	3,13	3,18	3,23	3,28
14-16	3,22	3,27	3,32	3,37	3,43	3,48	3,53	3,59	3,64	3,69	3,74	3,80
16-18	3,73	3,78	3,84	3,89	3,95	4,00	4,05	4,11	4,16	4,22	4,27	4,32
18-20	4,23	4,29	4,34	4,40	4,45	4,51	4,56	4,62	4,67	4,73	4,78	4,84
20-22	4,77	4,83	4,88	4,94	5,00	5,05	5,11	5,16	5,22	5,28	5,33	5,39
22-24	5,30	5,35	5,41	5,47	5,53	5,58	5,64	5,70	5,75	5,81	5,87	5,92
24-26	5,78	5,83	5,89	5,95	6,00	6,06	6,12	6,18	6,23	6,29	6,35	6,40
26-28	6,23	6,29	6,35	6,40	6,46	6,52	6,58	6,63	6,69	6,75	6,80	6,86
28-30	6,69	6,75	6,80	6,86	6,92	6,98	7,03	7,09	7,15	7,20	7,26	7,32
Height above waterline (in m)	Ship centre of lateral resistance below waterline (in m)											
	3,25	**3,50**	**3,75**	**4,00**	**4,25**	**4,50**	**4,75**	**5,00**	**5,25**	**5,50**	**5,70**	**6,00**
0-2	0,46	0,48	0,51	0,54	0,56	0,59	0,62	0,64	0,67	0,70	0,72	0,75
2-4	0,87	0,91	0,94	0,98	1,01	1,05	1,08	1,12	1,15	1,19	1,22	1,26
4-6	1,36	1,41	1,45	1,49	1,53	1,57	1,61	1,65	1,70	1,74	1,78	1,82
6-8	1,85	1,90	1,94	1,99	2,03	2,08	2,12	2,17	2,22	2,26	2,31	2,35
8-10	2,33	2,38	2,43	2,47	2,52	2,57	2,62	2,66	2,71	2,76	2,81	2,86
10-12	2,82	2,87	2,92	2,97	3,02	3,07	3,12	3,17	3,22	3,27	3,32	3,37
12-14	3,34	3,39	3,44	3,49	3,54	3,59	3,64	3,69	3,75	3,80	3,85	3,90
14-16	3,85	3,90	3,95	4,01	4,06	4,11	4,17	4,22	4,27	4,32	4,38	4,43
16-18	4,38	4,43	4,49	4,54	4,59	4,65	4,70	4,76	4,81	4,86	4,92	4,97
18-20	4,89	4,95	5,00	5,06	5,11	5,17	5,22	5,28	5,33	5,39	5,44	5,50
20-22	5,44	5,50	5,56	5,61	5,67	5,72	5,78	5,84	5,89	5,95	6,01	6,06
22-24	5,98	6,04	6,10	6,15	6,21	6,27	6,32	6,38	6,44	6,49	6,55	6,61
24-26	6,46	6,52	6,58	6,63	6,69	6,75	6,80	6,86	6,92	6,98	7,03	7,09
26-28	6,92	6,98	7,03	7,09	7,15	7,20	7,26	7,32	7,38	7,43	7,49	7,55
28-30	7,38	7,43	7,49	7,55	7,60	7,66	7,72	7,83	7,83	7,89	7,95	8,00

APPENDIX 6 SEA-KEEPING

1 Introduction

1.1 General

1.1.1 This section applies to ships with typical hull shape. Ships of unusual type or design will be considered by the Society on a case by case basis.

The requirements are based on the assumption that a frequency domain strip theory sea-keeping code is being used for the calculations. If another type of sea-keeping code is applied, deviations from the requirements in the following may be accepted by the Society on a case by case basis.

1.2 Scope

1.2.1 The scope of the present appendix is to supply details on how the sea-keeping calculations are to be performed. Requirements are given primarily on how to perform the short term assessments, but also some recommendations concerning long term assessments are given.

The short term assessments comprise all analyses of the vessel behaviour in a single sea state, and thus short term assessments yield all necessary information for the determination of:

- Wetness index
- Slamming index
- Propeller emergence
- Motion Sickness Incidence
- Motion Induced Interruption
- RMS values of all ship motions and accelerations.

Long term assessments of the sea-keeping yield estimates of e.g. the long term distribution of the vertical bending moment.

2 Short term assessment

2.1 General

2.1.1 Short term assessments serve to analyse a ships sea-keeping behaviour in a given sea state. The sea states to consider for the required rule checks are defined in Sec 4.

2.2 Loading conditions

2.2.1 The sea-keeping verifications should be carried out for following loading conditions:

- Auxiliary ships: full load and operational condition
- Front and second line ships: operational condition.

2.3 Ship speed

2.3.1 The ship speed to be considered for the short term sea-keeping calculations should be taken as:

- The cruise speed, unless otherwise specified in the Regulatory Framework.

2.4 Wave spectrum

2.4.1 General

The wave spectrum to be applied in the short term sea-keeping calculations are based on the characteristics of the sea area where the ship is going to operate:

- Open ocean conditions: Bretschneider spectrum with both short and long crested sea,
- Limited fetch sea areas (e.g. North Sea): JONSWAP spectrum with short crested sea.

2.4.2 Bretschneider spectrum

The Bretschneider, or two parameter Pierson-Moskowitz spectrum, is defined as:

$$S(\omega) = \frac{H_S^2}{4\pi}\left(\frac{2\pi}{T_Z}\right)^4 \omega^{-5} \exp\left(-\frac{1}{\pi}\left(\frac{2\pi}{T_Z}\right)^4 \omega^{-4}\right)$$

where:

H_S : Significant wave height, in m.

ω : Angular wave frequency, in rad/s.

T_Z : Zero up-crossing period, in s.

2.4.3 JONSWAP spectrum

The JONSWAP spectrum is defined as:

$$S(\omega) = 173\frac{H_S^2 T_S (T_S\omega)^{-5}}{F_1 F_2^4} \exp(-692(F_2 T_S \omega)^{-4}) \cdot \gamma^{\exp[-(0,206 F_2 T_S \omega - 1)^2 / 2\sigma^2]}$$

where:

H_S : Significant wave height, in m.

ω : Angular wave frequency, in rad/s.

T_S : Mean wave period, in s.

γ : JONSWAP peakedness parameter

$$\sigma = \begin{cases} 0,07 \text{ for } \omega \le (0,206 F_2 T_S)^{-1} \\ 0,09 \text{ for } \omega > (0,206 F_2 T_S)^{-1} \end{cases}$$

The values of F_1 and F_2 are given in Tab 1.

Table 1 : F_1 and F_2 values as function of γ

γ	F_1	F_2
1	1,00	1,00
2	1,24	0,95
3	1,46	0,93
3,3 **(1)**	1,52	0,92
4	1,66	0,91
5	1,86	0,90
6	2,04	0,89
(1) Mean JONSWAP spectrum		

Unless otherwise agreed with the Society, the peakedness parameter γ should be taken to 3,3, corresponding to the mean JONSWAP spectrum.

2.4.4 Wave spreading

In case of short crested sea a spreading function is to be applied to the wave spectrum when calculating the spectral moments of the response processes. The spreading function is defined as:

$$D(\psi) = \frac{2}{\pi}\cos^2(\bar{\psi} - \psi)$$

where:

$\bar{\psi}$: Heading angle

ψ : Angle ranging from $\bar{\psi}$ -π/2 to $\bar{\psi}$ + π/2

2.5 Hydrodynamic model

2.5.1 Short term assessment of the sea-keeping behaviour will imply that RAO's (Response Amplitude Operators) are to be calculated for:

- A suitable range of wave frequencies to cover the range of the sea spectrum (typically 0.2 - 2.0 rad/s, with not less than 20 frequencies). Most frequencies are to be placed in the range where most wave energy is present, and the calculation of RAO's at irregular frequencies, or for wave frequencies where the encounter frequency approaches zero, are to be avoided.
- At least 12 evenly distributed heading angles: 0°, 30°, 60°, … , 330° (with 0° being following sea).

2.6 Spectral moments

2.6.1 The n'th order response spectral moments are to be determined as:

- **Short crested sea**

$$m_n = \int_0^{\infty}\int_{\bar{\psi}-\frac{\pi}{2}}^{\bar{\psi}+\frac{\pi}{2}} \left|\omega - \frac{\omega^2 V}{g}\cos\psi\right|^n |\phi(\omega)|^2 S(\omega) D(\psi) d\psi d\omega$$

- **Long crested sea**

$$m_n = \int_0^{\infty} \left|\omega - \frac{\omega^2 V}{g}\cos\psi\right|^n |\phi(\omega)|^2 S(\omega) d\omega$$

where:

V : Ship speed, in m/s

g : Gravity acceleration (g = 9.81 m/s^2)

ψ : Heading angle

D(ψ) : Spreading function

ϕ : RAO

S(ω) : Wave spectrum

ω : wave frequency, in rad/s.

2.7 RMS values

2.7.1 The Root Mean Square (RMS) value of a response is defined as:

$$RMS = \sqrt{m_0}$$

where m_0 is the zero'th order spectral moment of the response.

3 Long term assessment

3.1 General

3.1.1 Long term assessments serve to estimate long term distributions of the various ship responses, typically the wave induced amidships vertical bending moment.

Such a long term distribution can thence be used to obtain estimates of the extreme responses, e.g. the most probable largest response in 10^8 wave cycles.

3.2 Hydrodynamic model

3.2.1 Unless otherwise agreed with the Society, the long term assessments should be carried out with following hydrodynamic model:

- Zero forward speed
- Bretschneider wave spectrum
- Short crested sea
- A suitable range of wave frequencies to cover the range of the sea spectrum (typically 0.2 - 2.0 rad/s with not less than 20 frequencies). Most frequencies are to be placed in the range where most wave energy is present, and the calculation of RAO's at irregular frequencies is to be avoided
- At least 12 evenly distributed heading angles
- Uniform distribution of heading angles, meaning that the same probability (e.g. 1/12 if 12 heading angles are considered) is assigned to each considered heading
- Extreme responses are to be determined at 10^{-8} probability of exceeding.

3.3 Sea state scatter diagram

3.3.1 The scatter diagram to be applied in the spectral approach relates the probability of occurrence to a wide range of sea states, characterised by their significant wave height and zero up-crossing period.

When considering unrestricted service the scatter diagram shown in Tab 2 is to be applied. However, in case of ship with a restricted navigation notation, different scatter diagrams may be applied when agreed on with the Society.

Table 2 : Recommended sea state scatter diagram for unrestricted service

H_S	T_Z																		
	1,5	**2,5**	**3,5**	**4,5**	**5,5**	**6,5**	**7,5**	**8,5**	**9,5**	**10,5**	**11,5**	**12,5**	**13,5**	**14,5**	**15,5**	**16,5**	**17,5**	**18,5**	**SUM**
0,5	0	0	1,3	133,7	865,6	1186	634,2	186,3	36,9	5,6	0,7	0,1	0	0	0	0	0	0	3050
1,5	0	0	0	29,3	986	4976	7738	5569,7	2375,7	703,5	160,7	30,5	5,1	0,8	0,1	0	0	0	22575
2,5	0	0	0	2,2	197,5	2158,8	6230	7449,5	4860,4	2066	644,5	160,2	33,7	6,3	1,1	0,2	0	0	23810
3,5	0	0	0	0,2	34,9	695,5	3226,5	5675	5099,1	2838	1114,1	337,7	84,3	18,2	3,5	0,6	0,1	0	19128
4,5	0	0	0	0	6	196,1	1354,3	3288,5	3857,5	2685,5	1275,2	455,1	130,9	31,9	6,9	1,3	0,2	0	13289
5,5	0	0	0	0	1	51	498,4	1602,9	2372,7	2008,3	1126	463,6	150,9	41	9,7	2,1	0,4	0,1	8328
6,5	0	0	0	0	0,2	12,6	167	690,3	1257,9	1268,6	825,9	386,8	140,8	42,2	10,9	2,5	0,5	0,1	4806
7,5	0	0	0	0	0	3	52,1	270,1	594,4	703,2	524,9	276,7	111,7	36,7	10,2	2,5	0,6	0	2586
8,5	0	0	0	0	0	0,7	15,4	97,9	255,9	350,6	296,9	174,6	77,6	27,7	8,4	2,2	0,5	0,1	1309
9,5	0	0	0	0	0	0,2	4,3	33,2	101,9	159,9	152,2	99,2	48,3	18,7	6,1	1,7	0,4	0,1	626
10,5	0	0	0	0	0	0	1,2	10,7	37,9	67,5	71,7	51,5	27,3	11,4	4	1,2	0,3	0,1	285
11,5	0	0	0	0	0	0	0,3	3,3	13,3	26,6	31,4	24,7	14,2	6,4	2,4	0,7	0,2	0,1	124
12,5	0	0	0	0	0	0	0,1	1	4,4	9,9	12,8	11	6,8	3,3	1,3	0,4	0,1	0	51
13,5	0	0	0	0	0	0	0	0,3	1,4	3,5	5	4,6	3,1	1,6	0,7	0,2	0,1	0	21
14,5	0	0	0	0	0	0	0	0,1	0,4	1,2	1,8	1,8	1,3	0,7	0,3	0,1	0	0	8
15,5	0	0	0	0	0	0	0	0	0,1	0,4	0,6	0,7	0,5	0,3	0,1	0,1	0	0	3
16,5	0	0	0	0	0	0	0	0	0	0,1	0,2	0,2	0,2	0,1	0,1	0	0	0	1
SUM	0	0	1	165	2091	9280	19922	24879	20870	12898	6245	2479	837	247	66	16	3	1	100.0000

Note 1: H_S is the significant wave height and T_Z is the zero up-crossing period of the short term sea states. The probability of a sea state is given as fractions of 100.000.

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 of the Rules for the Classification of the Ships.

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 of the Rules for the Classification of the Ships.

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 of the Rules for the Classification of the Ships. 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/mm^2 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] of the Rules for the Classification of the Ships.

2.2 Information to be kept on board

2.2.1 A plan indicating the steel types and grades adopted for the hull structures is to be kept on board. 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.

Table 1 : Mechanical properties of hull steels *(1/1/2025)*

Steel grades	Minimum yield stress R_{eH}, in N/mm^2	Ultimate minimum tensile strength R_m, in N/mm^2
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] of the Rules for the Classification of the Ships		

2.3 Material factor k

2.3.1 General *(1/1/2025)*

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/mm^2 or greater than 460 N/mm^2 are considered by the Society on a case by case basis.

Table 2 : Material factor k *(1/1/2025)*

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 For the purpose of the selection of steel grades to be used for the various structural members, the latter are divided into categories (SECONDARY, PRIMARY and SPECIAL), as indicated in Tab 3.

Tab 3 also specifies the classes (I, II and III) of the materials to be used for the various categories of structural members.

2.4.2 Materials are to be of a grade not lower than that indicated in Tab 4, or in Tab 5 for front line or second line ships depending on the material class and structural member gross thickness (see [2.4.5]).

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

2.4.4 Single strakes required to be of class III or of grade E/EH are to have a breadth within 0,4L amidships not less than (800+5L) mm, but not necessarily greater than 1800 mm.

2.4.5 *(1/1/2017)*

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

2.4.6 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.

2.4.7 In specific cases, such as [2.4.8], 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.

2.4.8 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.

Table 3 : Application of material classes and grades *(1/1/2017)*

Structural member category	Material class or grade	
	Within 0,4L amidships	Outside 0,4L amidships
SECONDARY: Lower strake in longitudinal bulkhead Deck plating exposed to weather (in general) Side plating	I	A / AH **(6)**
PRIMARY: Bottom plating (including keel plate) Strength deck plating **(1)** Continuous longitudinal plating of strength members above strength deck (excluding continuous longitudinal hatch coamings of ships equal to or greater than 90 m in length) Upper strake in longitudinal bulkhead Vertical strake (hatch side girder) and upper sloped strake in topside tank	II	A / AH **(7)**
SPECIAL: Sheer strake at strength deck **(2)** Stringer plate in strength deck **(2)** Deck strake at longitudinal bulkhead Bilge strake **(3)** **(4)** Continuous longitudinal hatch coamings of ships equal to or greater than 90 m in length **(5)**	III	II **(8)** (I outside 0,6L amidships)

(1) 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.
(2) To be not less than grade E/EH within 0,4L amidships in ships with length exceeding 250 m.
(3) May be of class II in ships with a double bottom over the full breadth and with length less than 150 m.
(4) To be not less than grade D/DH in ships with lenght exceeding 250 m.
(5) To be not less than grade D/DH.
(6) To be of class I for “front line or second line ships”
(7) To be of class II for “front line and second line ships”
(8) To be of class III for “front line and second line ships”

Note 1: Plating materials for sternframes, rudders, rudder horns and shaft brackets are generally to be of grades not lower than those 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.

Note 2: Bedplates of seats for propulsion and auxiliary engines inserted in the inner bottom are to be of class I. In other cases, the steel may generally be of grade A. Different grades may be required by the Society on a case by case basis.

Note 3: Plating at corners of large hatch openings on decks located below the strength deck, in the case of hatches of holds for refrigerated cargoes, and insert plates at corners of large openings on side shell plating are generally to be of class III.

Table 4 : 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”.						

Table 5 : Material grade requirements for classes I, II and III, for ships having the service notation front line or second line

Class	I	II **(1)**	III **(1)**
Any value of gross thickness	HSS	HSS	HSS
	DH	EH or DH	EH or DH
(1) EH for large gross thickness on a case by case basis **Note 1:** “HSS” means “Higher Strength Steel”			

2.4.9 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.

2.4.10 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.

2.4.11 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 of the Rules for the Classification of the Ships.

2.4.12 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.

2.4.13 For certain uses, grade B steel with controlled toughness at 0°C may be required for plates of gross thickness less than 30 mm.

2.4.14 *(1/7/2011)*
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 *(1/1/2025)*
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 *(1/1/2025)*
The design temperature t_D is to be taken as the lowest mean daily average air temperature in the area of operation, where:

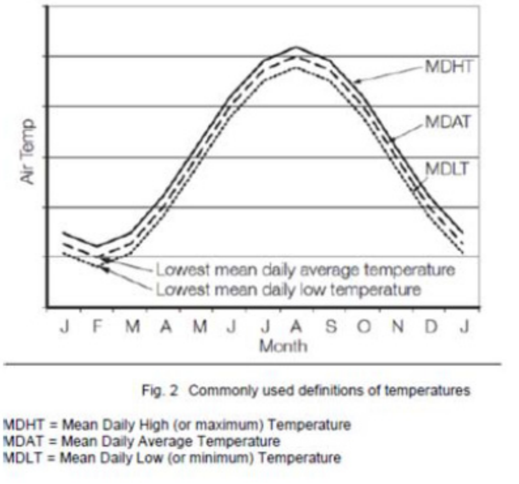
Mean : Statistical mean over observation period ()
Average : Average during one day and night
Lowest : Lowest during one year

Fig 1 illustrates the temperature definition.

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

Figure 1 :

Figure 2 : Commonly used definitions of temperatures *(1/1/2025)*



2.5.3 *(1/1/2025)*
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, the latter are divided into categories

(SECONDARY, PRIMARY and SPECIAL), as indicated in Tab 6.

Tab 6 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 5 of Tab 7) and structures below the lowest ballast waterline, see [2.4].

Table 6 : Application of material classes and grades structures exposed to low air temperatures *(1/1/2025)*

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)** (5)	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)** (5) Topside tank bulkhead above T_B **(1)** (5)	II	I
SPECIAL: Sheer strake at strength deck **(3)** Stringer plate in strength deck **(3)** Deck strake at longitudinal bulkhead Continuous longitudinal hatch coamings of ships equal to or greater than 90 m in length **(4)**	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) To be not less than grade D/DH.
(5) 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.
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].

2.5.4 Materials may not be of a lower grade than that indicated in Tab 7 to Tab 9 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.

2.6 Grades of steel within refrigerated spaces

2.6.1 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 10, 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 Irrespective of the provisions of [2.6.1], [2.6.2] and Tab 10, steel having grades lower than those required in [2.4], Tab 3, Tab 4 and Tab 5 in relation to the class and gross thickness of the structural member considered, may not be used.

Table 7 : Material grade requirements for class I at low temperatures *(1/1/2025)*

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	AH	D	DH	D	DH	E	EH
25 < t ≤ 30	B	AH	D	AH	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 8 : Material grade requirements for class II at low temperatures *(1/1/2025)*

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 9 : Material grade requirements for class III at low temperatures *(1/1/2025)*

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	ϕ	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 10 : Material grade requirements for members within or adjacent to refrigerated spaces *(1/1/2025)*

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 of the Rules for the Classification of the Ships.

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 of the Rules for the Classification of the Ships.

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 of the Rules for the Classification of the Ships, the above steels for forging are assigned to class 1 (see Pt D, Ch 2, Sec 3, [1.2] of the Rules for the Classification of the Ships).

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 of the Rules for the Classification of the Ships, 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 of the Rules for the Classification of the Ships.

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] of the Rules for the Classification of the Ships, 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 of the Rules for the Classification of the Ships.

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] of the Rules for the Classification of the Ships.).

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 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 11

$R_{p0,2}$: 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.

Table 11 : Joint coefficient for aluminium alloys

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 12.

Note 1:

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

Table 12 : Aluminium alloys Metallurgical efficiency coefficient β

Aluminium alloy	Temper condition	Gross thickness, in mm	β
6005 A (Open sections)	T5 or T6	$t \leq 6$	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

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 of the Rules for the Classification of the Ships..

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 of the Rules for the Classification of the Ships.

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.

SECTION 2 NET SCANTLING APPROACH

Symbols

t_C : Rule corrosion addition, in mm, see [3]

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 of bow and inner doors in Ch 8, Sec 5
- the scantlings of side doors and stern doors in Ch 8, Sec 6
- the scantlings of rudder structures and hull appendages in Chapter 9,
- the scantling of massive pieces made of steel forgings, steel castings or iron castings,

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 without providing the corrosion aditions, 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 plating which constitutes primary supporting members is to be obtained by deducting $0,5t_c$ from the gross thickness.

2.1.6 Hull girder net strenght characteristics

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].

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

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.

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.

Table 2 : Corrosion additions t_c, in mm, for each exposed side *(1/1/2017)*

Compartment type		General **(1)**	Special cases
Ballast tank		1,00	1,25 in upper zone **(2)**
Cargo tank and fuel oil tank	Plating of horizontal surfaces	0,75	1,00 in upper zone **(2)**
	Plating of non-horizontal surfaces	0,50	1,00 in upper zone **(2)**
	Ordinary stiffeners and primary supporting members	0,75	1,00 in upper zone **(2)**
Accommodation space		0,00	
Compartments other than those mentioned above		0,00	
Outside sea and air		0,50	0,00 **(3)**

(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) 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.
(3) For surfaces 1.0 m above the design waterline, provided that the surfaces are adequately protected against corrosion

SECTION 3 STRENGTH PRINCIPLES

Symbols

E : Young's modulus, in N/mm^2, to be taken equal to:

- for steels in general:

  $E = 2,06.10^5$ N/mm^2

- for stainless steels:

  $E = 1,95.10^5$ N/mm^2

- for aluminium alloys:

  $E = 7,0.10^4$ N/mm^2

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 cm^3, 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 cm^4, 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 cm^4, 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 8, Sec 1 and Ch 8, Sec 2) and machinery space (see Ch 8, Sec 3)
- in way of ends of superstructures (see Ch 8, 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. 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 When a higher strength steel is adopted at deck, members not contributing to the longitudinal strength and welded on 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] of the Rules for the Classification of the Ships).

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 11, 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:

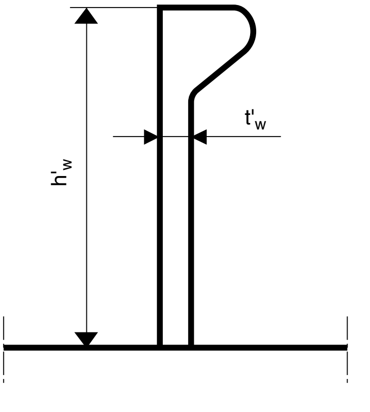
h'_w , t'_w : Height and net thickness of the bulb section, in mm, as shown in Fig 1

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

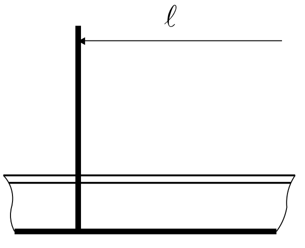


Figure 3 : Ordinary stiffener with a stiffener at one end

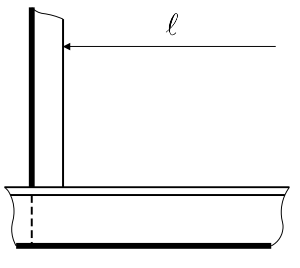


Figure 4 : Ordinary stiffener with end bracket

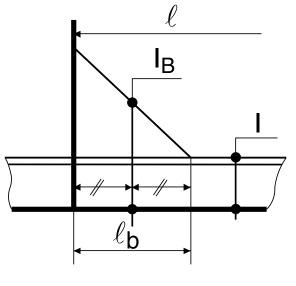
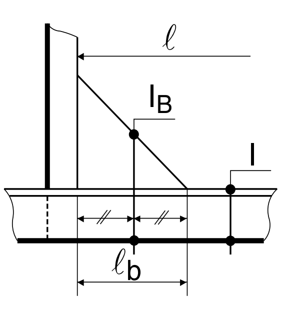


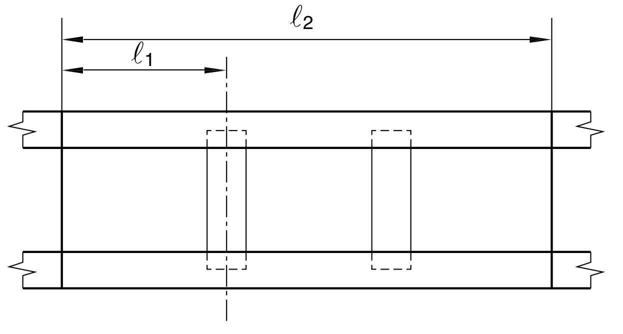
Figure 5 : Ordinary stiffener with a bracket and a stiffener at one end



3.2.2 Open floors

8The span ℓ of transverse ordinary stiffeners connected by struts is to be taken as the greater of 1,4ℓ_1 and 0,7ℓ_2, where ℓ_1 and ℓ_2 are the spans defined in Fig 6.

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



3.3 Width of attached plating

3.3.1 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):

  $b_P = 0,5s$.

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:

$$A_a \geq t_f b_f$$

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

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

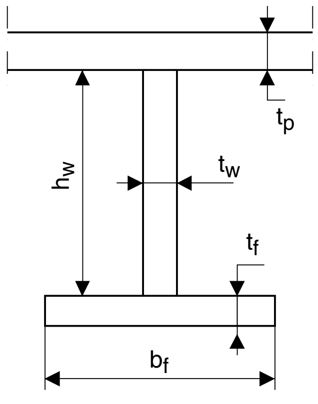
where:

A_a : Net sectional area, in mm², of the attached plating.

The net shear sectional area of a built section with attached lating is to be obtained, in cm², 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 cm^3, 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 cm^4, from the following formula:

$I = w\,v$

3.4.2 Corrugations

The net section modulus of a corrugation is to be obtained, in cm^3, from the following formula:

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

where:

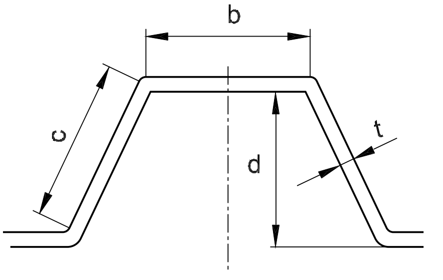
t : Net thickness of the plating of the corrugation, in mm

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

Where the web continuity is not ensure at ends of the bulkhead, the net section modulus of a corrugation is to be obtained, in cm^3, from the following formula :

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

Figure 8 : Dimensions of a corrugation



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

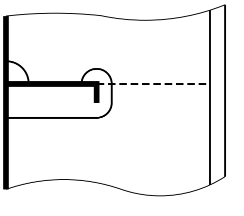


Figure 10 : End connection of ordinary stiffener Collar plate

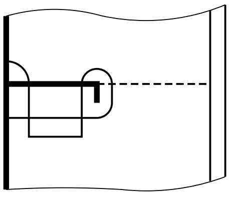


Figure 11 : End connection of ordinary stiffener One large collar plate

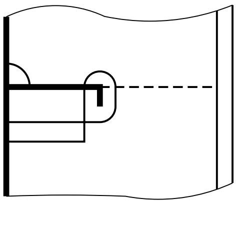
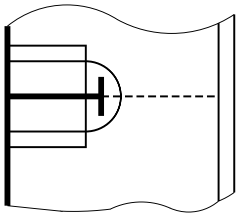


Figure 12 : End connection of ordinary stiffener Two large collar plates

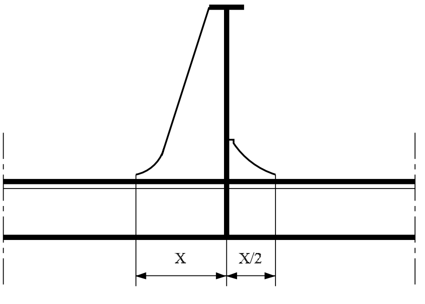


3.5.2 Where ordinary stiffeners are cut at primary supporting members, brackets are to be fitted to ensure the structural continuity. Their net section modulus and their net sectional area are to be not less than those of the ordinary stiffeners.

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 cm^2, 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):

  $b_P = 0{,}5 \min(s; 0{,}2\ell)$

4.3 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], reducing the web height h_w by the depth of the cut-out for the passage of ordinary stiffeners, if any (see [4.6.1]).

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], reducing the web height h_w by the depth of the cut-out for the passage of ordinary stiffeners, if any (see [4.6.1]).

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 cm^2, from the following formula:

$$A_{Sh} = \frac{A_{Sh1}}{1+\dfrac{0{,}0032\,\ell^2 A_{Sh1}}{I_1}} + \frac{A_{Sh2}}{1+\dfrac{0{,}0032\,\ell^2 A_{Sh2}}{I_2}}$$

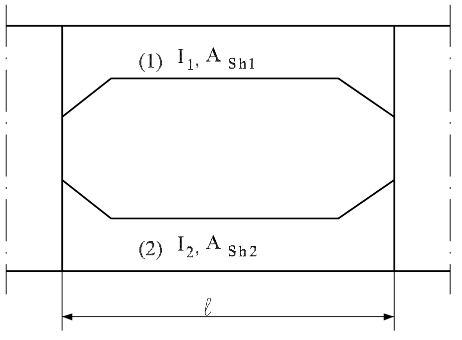
where (see Fig 14):

I_1, I_2 : Net moments of inertia, in cm^4, 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 cm^2, 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.

4.6.3 Openings may not be fitted in way of toes of end brackets.

Figure 15 : Bracketless end connections of primary supporting members

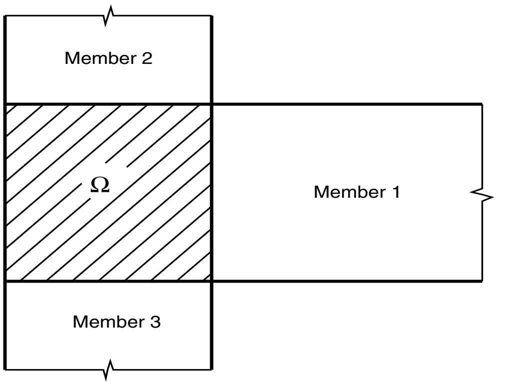
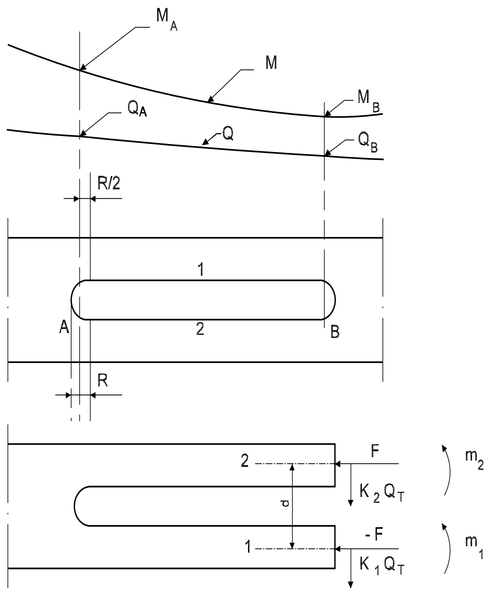


Figure 16 : Large openings in primary supporting members - Secondary stresses



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

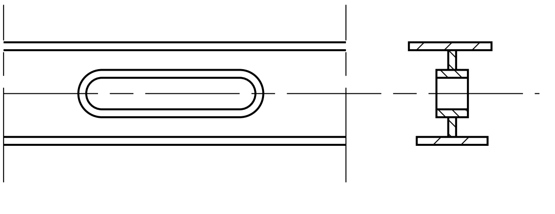


Figure 18 : Stiffening of large openings in primary supporting members - Solution 2

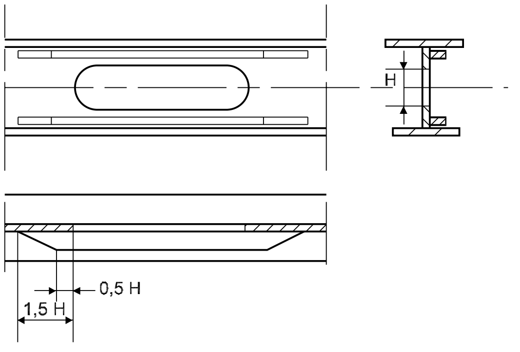
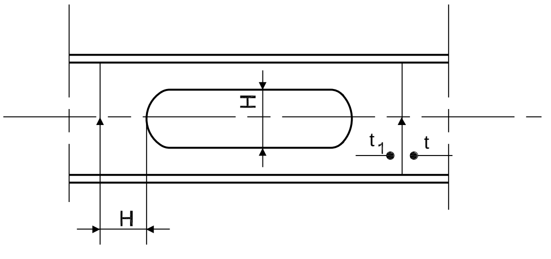


Figure 19 : Stiffening of large openings in primary supporting members - Solution 3



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 cm², from the following formula:

$$A = 0,1k_1(\gamma_{S2}p_S + \gamma_{W2}p_W)s\ell$$

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]

γ_{S2}, γ_{W2} : Partial safety factors, defined in Ch 7, Sec 2, 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.

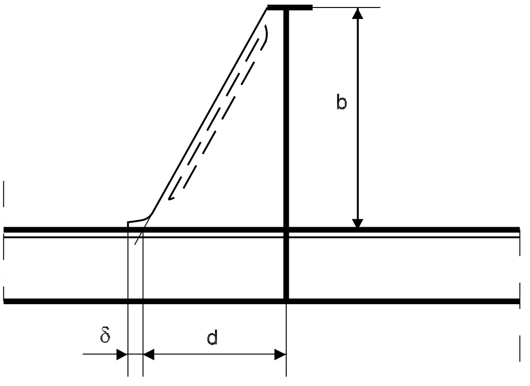
It is recommended that the bracket toe should be designed as shown in Fig 20.

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 general the bottom is to be longitudinally framed.

1.2.2 The bottom structure is to be checked by the Designer to make sure that it withstands the loads resulting from the dry-docking of the ship.

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:

$$b = 0,8 + 0,5\frac{L}{100}$$

The keel is to be longitudinally extended as far as practicable and at least for 0,5 L amidship.

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 0,7 m:

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 In ships subject to subdivision requirements, such bilge wells are to be fitted so that the distance of their bottom from the shell plating is not less than 460 mm.

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.

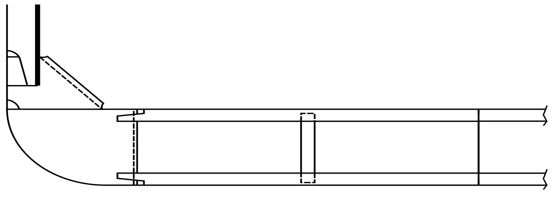
5.4 Open floors

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

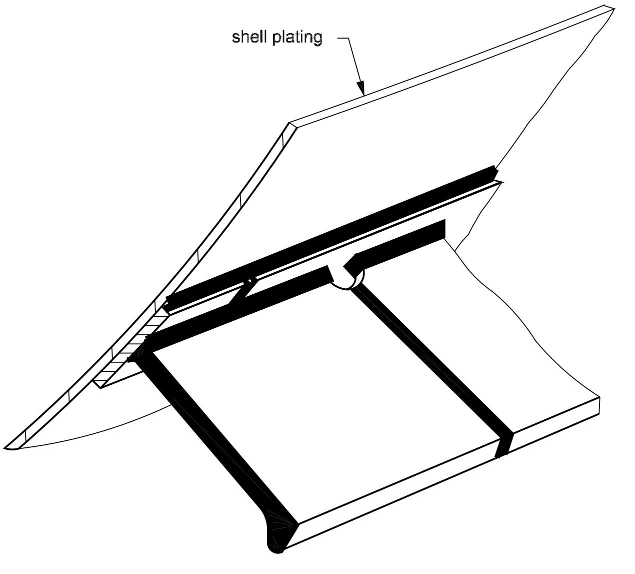
6.1.1 Arrangement

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°.

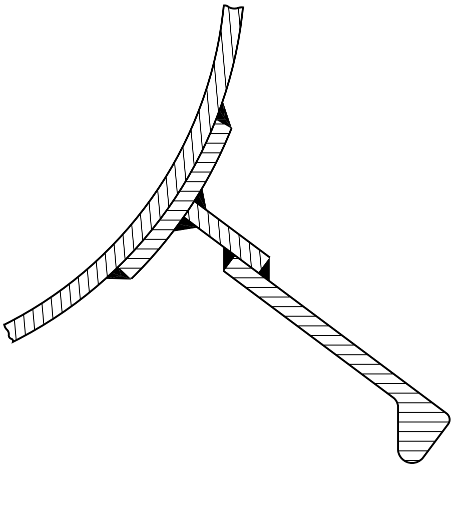
The arrangement shown in Fig 2 is recommended.

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 11, 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 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.

1.2.3 The side structure is to be checked by the Designer to make sure that it withstands the loads resulting from the push imposed by tugs during berthing operations without causing permanent deformation to the side structures.

If side marked zones, purposely designed for tug push are not foreseen, the side structures, at least within 1 m above 1 m from the deep waterline, should be able to withstand the following pressure P_T, in kN/m², assuming the structural model and checking criteria of the relevant sections of Chapter 7.

$$P_T = 0,012\Delta$$

where:

Δ : deep displacement, in t.

For ships having significantly difference between the light waterline and the deep waterline, the extension of the zone to be designed specially for push purpose will be specially considered.

1.3 Sheerstrake

1.3.1 The width of the sheerstrake is to be not less than the value obtained, in m, from the following formula (see also Sec 1, [2.4.4] :

$$b = 0,715 + 0,425\frac{L}{100}$$

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

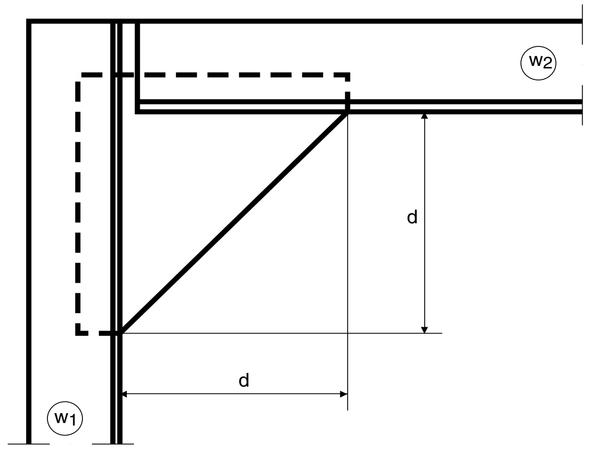
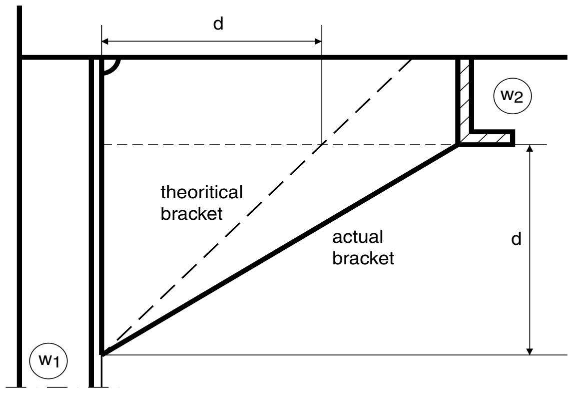


Figure 2 : Connections of stiffeners located in perpendicular planes



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 $w_2 \leq w_1$

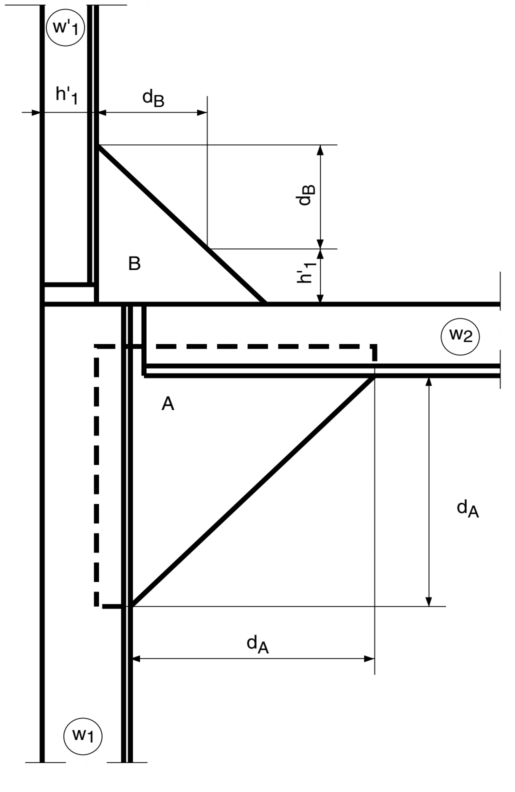
$w_A = w_2$ if $w_2 > w_1$

- 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.

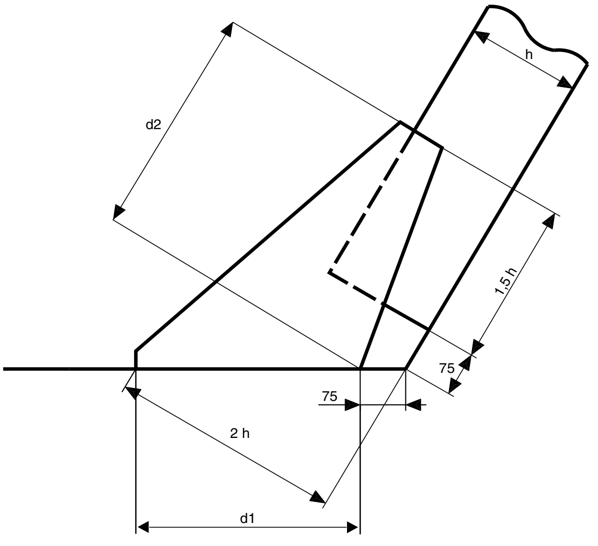
See also Sec 6, Fig 1.

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, [2.4.4] and 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

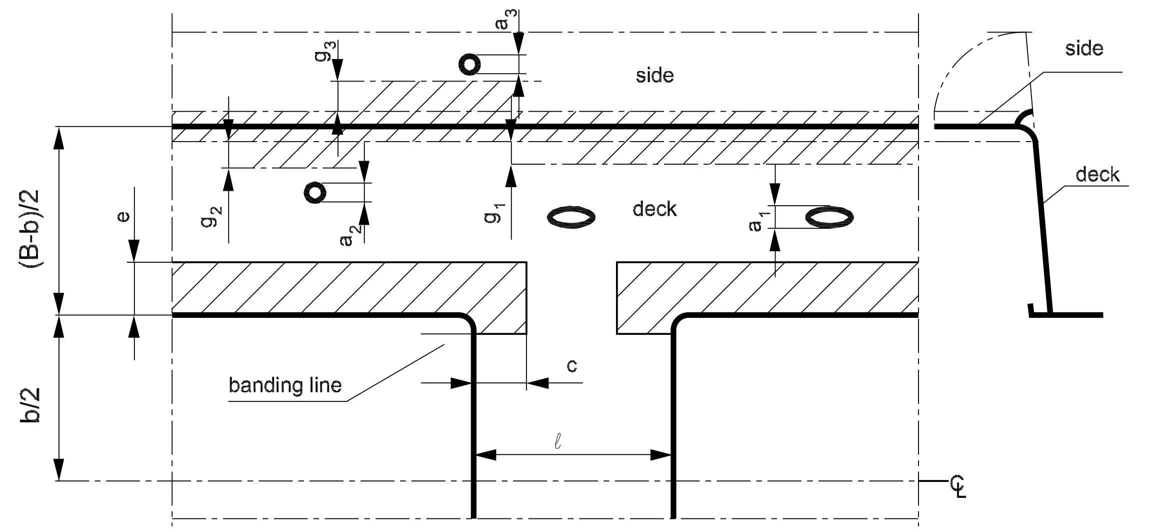
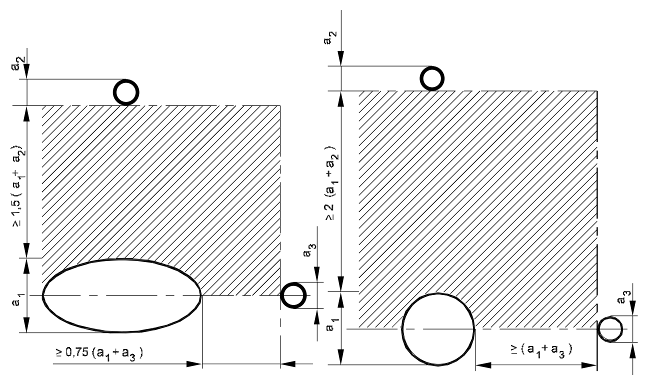


Figure 2 : Circular openings in the strength deck



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 3.1 of Ch 11, App 2 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 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.

1.2.3 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.

1.2.4 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.

1.2.5 The structural continuity of the bulkhead vertical and horizontal primary supporting members with the surrounding supporting structures is to be carefully ensured.

1.2.6 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 *(1/1/2025)*

Openings may not be cut in the collision bulkhead below the bulkhead deck

The number of openings in the collision bulkhead above the bulkhead 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 *(1/1/2025)*

Certain openings below the bulkhead 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 *(1/7/2011)*

Watertight doors are to comply with Ch 2, Sec 1, [6].

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 A primary supporting member is to be provided in way of any vertical knuckle in longitudinal bulkheads. The distance between the knuckle and the primary supporting member is to be taken not greater than 70 mm.

2.1.5 Plate floors are to be fitted in the double bottom in way of plane transverse bulkheads.

2.1.6 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 midspan

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

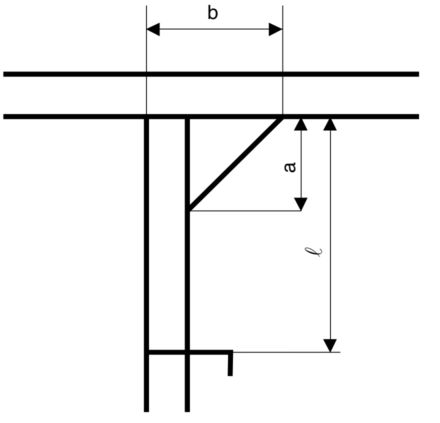
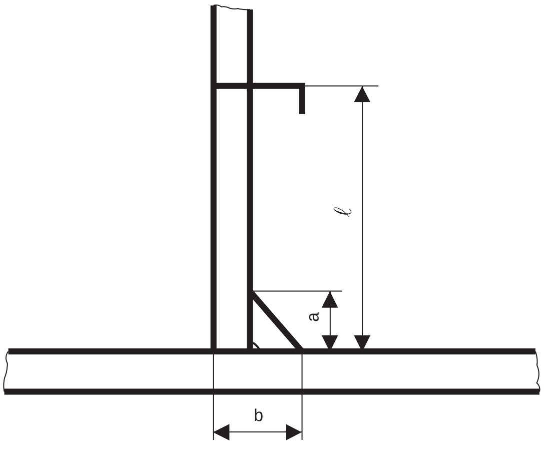


Figure 2 : Bracket at lower end of ordinary stiffener on plane bulkhead



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 *(1/1/2017)*

For the scantling of corrugated bulkheads reference is to be made to the the Rules for Classification of Ships.

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 "(i.e. those that are designed to sustain the loads transmitted by a deck structure) 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 %