Rules for the Classification of Steel Ships

PART B – Hull and Stability

Chapters 1 – 2 – 3 – 4

NR 467.B1 DT R07 E **July 2014**

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MARINE & OFFSHORE DIVISION
GENERAL CONDITIONS

ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine & Offshore Division (the "Society") is the classification (" Classification ") of any ship or vessel or offshore unit or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

- "prepares and publishes Rules for classification, Guidance Notes and other documents (" Rules ");
- "issues Certificates, Attestations and Reports following its interventions (" Certificates ");
- "publishes Registers.

1.2. - The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as " Certification ".

1.3. - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

1.4. - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as " Services ". The party and/or its representative requesting the services is hereinafter referred to as the " Client ". **The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.**

1.5. - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Shipbuilder, Repair yard, Charterer or Shipowner who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

ARTICLE 2

2.1. - Classification is the appraisement given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisement is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

2.2. - Certification is carried out by the Society along the same lines as set out in Articles 3 and 4 hereafter and with reference to the applicable National and International Regulations or Standards.

2.3. - **It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraisement or cause to modify its scope.**

2.4. - The Client is to give to the Society all access and information necessary for the safe and efficient performance of the requested Services. The Client is the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out.

ARTICLE 3

3.1. - **The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are a collection of minimum requirements but not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.**

Committees consisting of personalities from the Industry contribute to the development of those documents.

3.2. - **The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.**

3.3. - The Services of the Society are carried out by professional Surveyors according to the applicable Rules and to the Code of Ethics of the Society. Surveyors have authority to decide locally on matters related to classification and certification of the Units, unless the Rules provide otherwise.

3.4. - **The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.**

ARTICLE 4

4.1. - The Society, acting by reference to its Rules:

- "reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- "conducts surveys at the place of their construction;
- "classes Units and enters their class in its Register;
- "surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.

ARTICLE 5

5.1. - **The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.**

5.2. - **The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for.**

In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

5.3. - **The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder.**

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

ARTICLE 6

6.1. - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

6.2. - **If the Services of the Society or their omission cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee. These limits apply regardless of fault including breach of contract, breach of warranty, tort, strict liability, breach of statute, etc.**

The Society bears no liability for indirect or consequential loss whether arising naturally or not as a consequence of the Services or their omission such as loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

6.3. - All claims are to be presented to the Society in writing within three months of the date when the Services were supplied or (if later) the date when the events which are relied on of were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred. Time is to be interrupted thereafter with the same periodicity.

ARTICLE 7

7.1. - Requests for Services are to be in writing.

7.2. - **Either the Client or the Society can terminate as of right the requested Services after giving the other party thirty days' written notice, for convenience, and without prejudice to the provisions in Article 8 hereunder.**

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. here above subject to compliance with 2.3. here above and Article 8 hereunder.

7.4. - The contract for classification and/or certification of a Unit cannot be transferred neither assigned.

ARTICLE 8

8.1. - The Services of the Society, whether completed or not, involve, for the part carried out, the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

8.2. - **Overdue amounts are increased as of right by interest in accordance with the applicable legislation.**

8.3. - **The class of a Unit may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.**

ARTICLE 9

9.1. - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

- "Clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the **classification file** consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit ;
- "copy of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society, where appropriate, in case of the Unit's transfer of class;
- "the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units, as well as general technical information related to hull and equipment damages, may be passed on to IACS (International Association of Classification Societies) according to the association working rules;
- "the certificates, documents and information relative to the Units classed with the Society may be reviewed during certificating bodies audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

ARTICLE 10

10.1. - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

ARTICLE 11

11.1. - In case of diverging opinions during surveys between the Client and the Society's surveyor, the Society may designate another of its surveyors at the request of the Client.

11.2. - Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Marine Advisory Committee.

ARTICLE 12

12.1. - Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

12.2. - Disputes arising out of the payment of the Society's invoices by the Client are submitted to the Court of Nanterre, France, or to another Court as deemed fit by the Society.

12.3. - **Other disputes over the present General Conditions or over the Services of the Society are exclusively submitted to arbitration, by three arbitrators, in London according to the Arbitration Act 1996 or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by English law.**

ARTICLE 13

13.1. - **These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement. They are not varied by any purchase order or other document of the Client serving similar purpose.**

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

13.3. - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.

RULES FOR THE CLASSIFICATION OF SHIPS

Part B
Hull and Stability

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

July 2014

The English wording of these rules take precedence over editions in other languages.

Unless otherwise specified, these rules apply to ships for which contracts are signed after July 1st, 2014. The Society may refer to the contents hereof before July 1st, 2014, as and when deemed necessary or appropriate.

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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 monohull displacement ships of normal form, speed and proportions, made in welded steel construction, excluding ships covered by NR600 "Hull Structure and Arrangement for the Classification of Cargo Ships less than 65 m and Non Cargo Ships less than 90 m".

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.

Note 1: NR600 is applicable for:

- cargo ships with length less than 65 m, and
- non cargo ships with length less than 90 m.

The wording "cargo ships" and "non-cargo ships" used in NR600 means:

- Cargo ships: ships liable to carry cargoes and having a deadweight greater than 30% of the total displacement. As a general rule, these ships are fitted with cargo holds, tanks and ballast tanks (i.e bulk or ore carriers, oil or chemical tanker, container ship, general cargo ship, ...) and the value of the block coefficient is greater than 0,75.
- Non-cargo ships: type of ships other than cargo ships defined here above.

Note 2: NR600 is not applicable for liquefied gas carriers, ships for dredging activities and any cargo ships with alternate light and heavy cargo loading conditions.

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

1.1.5 Where scantlings are obtained from direct calculation procedures which are different from those specified in Part B, Chapter 7, adequate supporting documentation is to be submitted to the Society, as detailed in Ch 1, Sec 3.

1.2 Limits of application to lifting appliances

1.2.1 The fixed parts of lifting appliances, considered as an integral part of the hull, are the structures permanently connected by welding to the ship's hull (for instance crane pedestals, masts, king posts, derrick heel seatings, etc., excluding cranes, derrick booms, ropes, rigging accessories, and, generally, any dismountable parts). The shrouds of masts embedded in the ship's structure are considered as fixed parts.

1.2.2 The fixed parts of lifting appliances and their connections to the ship's structure are covered by the Rules, even when the certification (especially the issuance of the Cargo Gear Register) of lifting appliances is not required.

2 Rule application

2.1 Ship parts

2.1.1 General

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

- fore part
- central part
- aft part.

2.1.2 Fore part

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

- the fore peak structures
- the stems.

In addition, it includes:

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

2.1.3 Central part

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

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

2.1.4 Aft part

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

2.2 Rules applicable to various ship parts

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

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

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

2.3 Rules applicable to other ship items

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

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

Item	Applicable Chapters and Sections
Machinery space	Ch 8, Sec 3
Superstructures and deckhouses	Ch 8, Sec 4
Bow doors and inner doors	Ch 8, Sec 5
Side shell doors and stern doors	Ch 8, Sec 6
Large hatch covers	Ch 8, Sec 7
Small hatches	Ch 8, Sec 8
Movable decks and inner ramp External ramps	Ch 8, Sec 9
Arrangement of hull and superstructures openings	Ch 8, Sec 10
Helicopter decks	Ch 8, Sec 11
Rudders	Ch 9, Sec 1
Other hull outfitting	Ch 9, Sec 2 Ch 9, Sec 3 Ch 9, Sec 4

3 Rounding off of scantlings

3.1

3.1.1 Plate thicknesses

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

a) the net thickness (see Ch 4, Sec 2) is calculated in accordance with the rule requirements.

b) corrosion addition t_C (see Ch 4, Sec 2) is added to the calculated net thickness, and this gross thickness is rounded off to the nearest half-millimetre.

c) the rounded net thickness is taken equal to the rounded gross thickness, obtained in b), minus the corrosion addition t_C.

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 modulus	Z	m^3
Density	ρ	t/m^3
Concentrated loads	P	kN
Linearly distributed loads	q	kN/m
Surface distributed loads (pressures)	p	kN/m^2
Thicknesses	t	mm
Span of ordinary stiffeners and primary supporting members	ℓ	m
Spacing of ordinary stiffeners and primary supporting members	s	m
Bending moment	M	kN·m
Shear force	Q	kN
Stresses	σ, τ	N/mm^2
Section modulus of ordinary stiffeners and primary supporting members	w	cm^3
Sectional area of ordinary stiffeners and primary supporting members	A	cm^2

2 Symbols

2.1

2.1.1

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

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

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

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

L_S : Subdivision length, in m, defined in [3.3]

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

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

T : Moulded draught, in m, defined in [3.7]

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

C_B : Total block coefficient:

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

3 Definitions

3.1 Rule length

3.1.1 The rule length L is the distance, in m, measured on the summer load waterline, from the fore-side of the stem to the after side of the rudder post, or to the centre of the rudder stock where there is no rudder post. L is to be not less than 96% and need not exceed 97% of the extreme length on the summer load waterline.

3.1.2 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 summer load waterline.

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

3.1.4 Ends of rule length

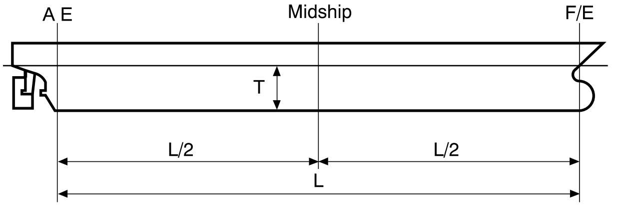
The fore end (FE) of the rule length L, see Fig 1, is the perpendicular to the summer load waterline at the forward side of the stem.

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

3.1.5 Midship

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

Figure 1 : Ends and midship

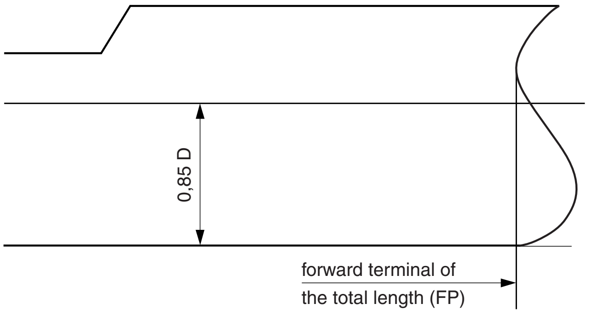


3.2 Load line length

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

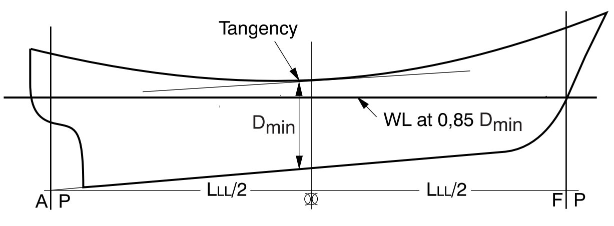
3.2.2 *Where the stem contour is concave above the waterline at 85% of the least moulded depth, both the forward terminal of the total length and the fore-side of the stem respectively is taken at the vertical projection to that waterline of the aftermost point of the stem contour (see Fig 2).*

Figure 2 : Concave stem contour Forward terminal of length



3.2.3 *In ship design with a rake of keel, the waterline on which this length is measured is parallel to the designed waterline at 85% of the least moulded depth D_{min} found by drawing a line parallel to the keel line of the ship (including skeg) tangent to the moulded sheer line of the freeboard deck.The least moulded depth is the vertical distance measured from the top of the keel to the top of the freeboard deck beam at side at the point of tangency (see Fig 3).*

Figure 3 : Length of ships with a rake of keel



3.3 Subdivision length

3.3.1 *The subdivision L_S of the ship is the greatest projected moulded length of that part of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught.*

3.4 Moulded breadth

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

3.5 Depth

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

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

3.6 Moulded depth

3.6.1 *The moulded depth D_1 is the vertical distance measured from the top of the keel to the top of the freeboard deck beam at side. Where the form at the lower part of the midship section is of a hollow character or where thick garboards are fitted, the distance is measured from the point where the line of the flat of the bottom continued inwards cuts the side of the keel.*

In ships having rounded gunwales, the moulded depth is to be measured to the point of intersection of the moulded lines of deck and sides, the lines extending as though the gunwales were of angular design.

Where the freeboard deck is stepped and the raised part of the deck extends over the point at which the moulded depth is to be determined, the moulded depth is to be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.

3.7 Moulded draught

3.7.1 The moulded draught T is the distance, in m, measured vertically on the midship transverse section, from the moulded base line to the summer load waterline.

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

3.8 Lightweight

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

3.9 Deadweight

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

3.10 Freeboard deck

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

3.11 Bulkhead deck

3.11.1 *The bulkhead deck in a passenger ship means the uppermost deck at any point in the subdivision length L_S to which the main bulkheads and the ship's shell are carried watertight. In a cargo ship the freeboard deck may be taken as the bulkhead deck.*

3.12 Inner side

3.12.1 The inner side is the longitudinal bulkhead which limits the inner hull for ships fitted with double hull.

3.13 Superstructure

3.13.1 General

A superstructure is a decked structure connected to the freeboard deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 0,04 B.

3.13.2 Enclosed and open superstructure

A superstructure may be:

- enclosed, where:
  - it is enclosed by front, side and aft bulkheads complying with the requirements of Ch 8, Sec 4
  - all front, side and aft openings are fitted with efficient weathertight means of closing
- open, where it is not enclosed.

3.13.3 Bridge

A bridge is a superstructure which does not extend to either the forward or after perpendicular.

3.13.4 Poop

A poop is a superstructure which extends from the after perpendicular forward to a point which is aft of the forward perpendicular. The poop may originate from a point aft of the aft perpendicular.

3.13.5 Forecastle

A forecastle is a superstructure which extends from the forward perpendicular aft to a point which is forward of the after perpendicular. The forecastle may originate from a point forward of the forward perpendicular.

3.13.6 Full superstructure

A full superstructure is a superstructure which, as a minimum, extends from the forward to the after perpendicular.

3.14 Raised quarterdeck

3.14.1 *A raised quarterdeck is a partial superstructure of reduced height as defined in [3.19].*

It extends forward from the after perpendicular and has an intact front bulkhead (sidescuttles of the non-opening type fitted with efficient deadlights and bolted man hole covers).

Where the forward bulkhead is not intact due to doors and access openings, the superstructure is then to be considered as a poop.

3.15 Superstructure deck

3.15.1 *A superstructure deck is a deck forming the upper boundary of a superstructure.*

3.16 Deckhouse

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

3.17 Trunk

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

3.18 Well

3.18.1 *A well is any area on the deck exposed to the weather, where water may be entrapped. Wells are considered to be deck areas bounded on two or more sides by deck structures.*

3.19 Standard height of superstructure

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

Table 2 : Standard height of superstructure

Load line length L_{LL}, in m	Standard height h_S, in m	
	Raised quarter deck	All other superstructures
$L_{LL} \le 30$	0,90	1,80
$30 < L_{LL} < 75$	$0,9 + 0,00667 (L_{LL} - 30)$	1,80
$75 \le L_{LL} < 125$	$1,2 + 0,012 (L_{LL} - 75)$	$1,8 + 0,01 (L_{LL} - 75)$
$L_{LL} \ge 125$	1,80	2,30

3.20 Tiers of superstructures and deckhouses

3.20.1 The lowest tier is the tier located immediately above the freeboard deck.

The second tier is the tier located immediately above the lowest tier, and so on.

3.21 Type A and Type B ships

3.21.1 Type A ship

A Type A ship is one which:

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

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

3.21.2 Type B ship

All ships which do not come within the provisions regarding Type A ships stated in [3.21.1] are to be considered as Type B ships.

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

3.21.3 Type B-60 ship

A Type B-60 ship is any Type B ship of over 100 metres in length which, fulfilling the requirements *reported in Ch 3, App 4, [4.4], is assigned with a value of tabular freeboard which can be reduced up to 60 per cent of the difference between the "B" and "A" tabular values for the appropriate ship lengths.*

3.21.4 Type B-100 ships

A Type B-100 ship is any Type B ship of over 100 metres in length which, fulfilling the requirements *reported in Ch 3, App 4, [4.4], is assigned with a value of tabular freeboard which can be reduced up to 100 per cent of the difference between the "B" and "A" tabular values for the appropriate ship lengths.*

3.22 Positions 1 and 2

3.22.1 Position 1

Position 1 includes:

- *exposed freeboard and raised quarter decks,*
- *exposed superstructure decks situated forward of 0,25 L_{LL} from the perpendicular, at the forward side of the stem, to the waterline at 85% of the least moulded depth measured from the top of the keel.*

3.22.2 Position 2

Position 2 includes:

- *exposed superstructure decks situated aft of 0,25 L from the perpendicular, at the forward side of the stem, to the waterline at 85% of the least moulded depth measured from the top of the keel and located at least one standard height of superstructure above the freeboard deck,*
- *exposed superstructure decks situated forward of 0,25 L_{LL} from the perpendicular, at the forward side of the stem, to the waterline at 85% of the least moulded depth measured from the top of the keel and located at least two standard heights of superstructure above the freeboard deck.*

4 Reference co-ordinate system

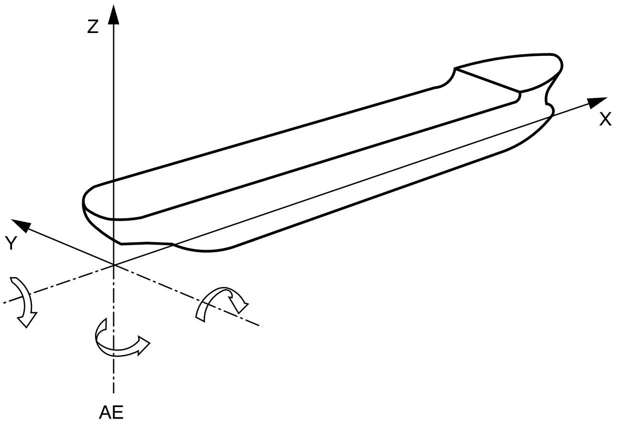
4.1

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

4.1.2 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 surveyed by the Society during the construction

1.1.1 Plans and documents to be submitted for approval

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

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, [1.6].

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.

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

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

1.2.1 Plans and documents to be submitted for approval

The plans required by the National Regulations concerned are to be submitted to the Society for approval, in addition to those in [1.1]. Such plans may include:

- arrangement of lifesaving appliances and relevant embarking and launching devices (davits and winches)
- arrangement of compasses
- arrangement of navigation lights
- order transmission
- loading and unloading arrangement to be included in the ILO Register
- forced ventilation in cargo spaces intended for the carriage of vehicles, dangerous goods in bulk or packaged form, etc.
- lashing of tank vehicles intended for the carriage of dangerous liquids
- cargo securing manual, where required.

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

2.1 General

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

2.2 Service notations

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

2.3 Additional class notations

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

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

Plan or document	Containing also information on
Midship section Transverse sections Shell expansion Decks and profiles Double bottom Pillar arrangements Framing plan Deep tank and ballast tank bulkheads, wash bulkheads	Class characteristics Main dimensions Minimum ballast draught Frame spacing Contractual service speed Density of cargoes Design loads on decks and double bottom Steel grades Location and height of air vent outlets of various compartments Corrosion protection Openings in decks and shell and relevant compensations Boundaries of flat areas in bottom and sides Details of structural reinforcements and/or discontinuities Bilge keel with details of connections to hull structures
Loading manual and loading instruments	See Ch 10, Sec 2, [3]
Watertight subdivision bulkheads Watertight tunnels	Openings and their closing appliances, if any
Fore part structure	Location and height of air vent outlets of various compartments
Transverse thruster, if any, general arrangement, tunnel structure, connections of thruster with tunnel and hull structures	
Aft part structure	Location and height of air vent outlets of various compartments
Machinery space structures Foundations of propulsion machinery and boilers	Type, power and r.p.m. of propulsion machinery Mass and centre of gravity of machinery and boilers
Superstructures and deckhouses Machinery space casing	Extension and mechanical properties of the aluminium alloy used (where applicable)
Bow doors, stern doors and inner doors, if any, side doors and other openings in the side shell	Closing appliances Electrical diagrams of power control and position indication circuits for bow doors, stern doors, side doors, inner doors, television system and alarm systems for ingress of water
Hatch covers, if any	Design loads on hatch covers Sealing and securing arrangements, type and position of locking bolts Distance of hatch covers from the summer load waterline and from the fore end
Movable decks and ramps, if any	
Windows and side scuttles, arrangements and details	
Scuppers and sanitary discharges	
Bulwarks and freeing ports	Arrangement and dimensions of bulwarks and freeing ports on the freeboard deck and superstructure deck
Helicopter decks, if any	General arrangement Main structure Characteristics of helicopters: maximum mass, distance between landing gears or landing skids, print area of wheels or skids, distribution of landing gear loads
Rudder and rudder horn **(1)**	Maximum ahead service speed
Sternframe or sternpost, sterntube Propeller shaft boss and brackets **(1)**	
Derricks and cargo gear Cargo lift structures	Design loads (forces and moments) Connections to the hull structures
Sea chests, stabiliser recesses, etc.	

(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].

Plan or document	Containing also information on
Hawse pipes	
Plan of outer doors and hatchways	
Plan of manholes	
Plan of access to and escape from spaces	
Plan of ventilation	Use of spaces
Plan of tank testing	Testing procedures for the various compartments Height of pipes for testing
Plan of watertight doors and scheme of relevant manoeuvring devices	Manoeuvring devices Electrical diagrams of power control and position indication circuits
Freeboard calculations	
Stability documentation	See Ch 3, Sec 1, [2.1]
Calculations relevant to intact stability and, where required, damage stability	
Equipment number calculation	Geometrical elements for calculation List of equipment Construction and breaking load of steel wires Material, construction, breaking load and relevant elongation of synthetic ropes
Emergency towing arrangement	See Ch 9, Sec 4, [4.3]
(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].	

Table 2 : Plans and documents to be submitted depending on service notations

Service notations	Plans or documents
Ro-ro passenger ship **Ro-ro cargo ship**	Plans of the bow or stern ramps, elevators for cargo handling and movable decks, if any, including: • structural arrangements of ramps, elevators and movable decks with their masses • arrangements of securing and locking devices • connection of ramps, lifting and/or hoisting appliances to the hull structures, with indication of design loads (amplitude and direction) • wire ropes and hoisting devices in working and stowed position • hydraulic jacks • loose gear (blocks, shackles, etc.) indicating the safe working loads and the testing loads • test conditions Operating and maintenance manual (see Ch 8, Sec 5 and Ch 8, Sec 6) of bow and stern doors and ramps Plan of arrangement of motor vehicles, railway cars and/or other types of vehicles which are intended to be carried and indicating securing and load bearing arrangements Characteristics of motor vehicles, railways cars and/or other types of vehicles which are intended to be carried: (as applicable) axle load, axle spacing, number of wheels per axle, wheel spacing, size of tyre print Plan of dangerous areas, in the case of ships intended for the carriage of motor vehicles with petrol in their tanks
Container ship	Container arrangement in holds, on decks and on hatch covers, indicating size and gross mass of containers Container lashing arrangement indicating securing and load bearings arrangements Drawings of load bearing structures and cell guides, indicating the design loads and including the connections to the hull structures and the associated structural reinforcements
Livestock carrier	Livestock arrangement Distribution of fodder and consumable liquid on the various decks and platforms
Oil tanker ESP **FLS tanker**	Arrangement of pressure/vacuum valves in cargo tanks Cargo temperatures
Tanker	Cargo temperatures

Service notations	Plans or documents
Chemical tanker ESP	List of cargoes intended to be carried, with their density Types of cargo to be carried in each tank Cargo temperatures Arrangement of pressure/vacuum valves in cargo tanks For ships with independent tanks, connection of the cargo tanks to the hull structure
Liquefied gas carrier	Arrangement of pressure/vacuum valves in cargo tanks Heat transfer analysis Distribution of steel qualities For ships with independent tanks: • cargo tank structure • connection of the cargo tanks to the hull structure • anti-floating and anti-collision arrangements
Dredger	Transverse sections through hoppers, wells, pump rooms and dredging machinery spaces Structural arrangement of hoppers and supporting structures Closing arrangements, if any Connection of dredging machinery with the hull structure
Hopper dredger **Hopper unit**	Transverse sections through hoppers, wells, pump rooms and dredging machinery spaces Structural arrangement of hoppers and supporting structures including: • location, mass, fore and aft extent of the movable dredging equipment, for each loading condition • calculations of the horizontal forces acting on the suction pipe and on the gallows Closing arrangements, if any Connection of dredging machinery with the hull structure
Split hopper dredger **Split hopper unit**	Transverse sections through hoppers, wells, pump rooms and dredging machinery spaces Structural arrangement of hoppers and supporting structures, including: • location, mass, fore and aft extent of the movable dredging equipment, for each loading condition • calculations of the horizontal forces acting on the suction pipe and on the gallows Closing arrangements, if any Connection of dredging machinery with the hull structure Superstructure hinges and connections to the ship's structure, including mass and location of the superstructure centre of gravity Structure of hydraulic jack spaces Deck hinges, including location of centre of buoyancy and of centre of gravity of each half-hull, mass of equipped half-hull, half mass of spoil or water, supplies for each half-hull and mass of superstructures supported by each half-hull Hydraulic jacks and connections to ship's structure including operating pressure and maximum pressure of the hydraulic jacks (cylinder and rod sides) and corresponding forces Longitudinal chocks of bottom and deck Transverse chocks Hydraulic installation of jacks, with explanatory note
Tug **Salvage tug** **Tug escort**	Connection of the towing system (winch and hook) with the hull structures with indication of design loads
Tug, **salvage tug**, **tug escort** with additional service feature **barge combined**, **Barge** with additional service feature **tug combined**	Structural arrangement of the fore part of the tug, showing details of reinforcements in way of the connecting point Structural arrangement of the aft part of the barge, showing details of reinforcements in way of the connecting point Details of the connection system
Supply vessel	General plan showing the location of storage and cargo tanks with adjacent cofferdams and indicating the nature and density of cargoes intended to be carried Plan of gas-dangerous spaces Connection of the cargo tanks with the hull structure Stowage of deck cargoes and lashing arrangement with location of lashing points and indication of design loads Structural reinforcements in way of load transmitting elements, such as winches, rollers, lifting appliances

Service notations	Plans or documents
Oil recovery ship	General plan showing the location of tanks intended for the retention of oily residues and systems for their treatment Plan of the system for treatment of oily residues and specification of all relevant apparatuses Supporting structures of the system for treatment of oily residues Operating manual
Cable laying ship	Structural reinforcements in way of load transmitting elements, such as foundations and fastenings of the equipment to the ship structures
Fishing vessel	Minimum design temperature of refrigerated spaces Structural reinforcements in way of load transmitting elements, such as masts, gantries, trawl gallows and winches, including the maximum brake load of the winches

Table 3 : Plans and documents to be submitted depending on additional class notations

Additional class notation	Plans or documents
ICE CLASS IA SUPER **ICE CLASS IA** **ICE CLASS IB** **ICE CLASS IC** **ICE CLASS ID**	The plans relevant to shell expansion and fore and aft part structures are to define (see Pt E, Ch 8, Sec 1, [2.2]) the maximum draught LWL, the minimum draught BWL (both draughts at midship, fore and aft ends), and the borderlines of fore, midship and aft regions defined in Pt E, Ch 8, Sec 2, [1.2]
LASHING	See Pt E, Ch 10, Sec 5, [1]
MON-HULL	See Pt E, Ch 5, Sec 1, [1.2]
SPM	See Pt E, Ch 10, Sec 4, [2]

SECTION 4 CALCULATION PROGRAMMES

1 Programme for the Rule based scantling

1.1 General

1.1.1 Computer programmes, dealing with rule checking, are available to the clients of the Society. They run on personal computers under the WINDOWS operating system.

The Head Office of the Society or a local office should be contacted in order to have information on how to obtain one of these programmes.

1.2 MARS

1.2.1 The MARS programme performs the rule scantling check of plating and ordinary stiffeners at any transverse section along the ship hull.

1.2.2 In particular, MARS allows 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.

1.3 VERISTAR

1.3.1 Within VERISTAR system, the Society provides an integrated chain of computer programmes to perform rational design analysis of ship hulls.

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

1.4 BULK

1.4.1 The BULK programme is designed to assess, according to the IACS Unified Requirements adopted in the rules, the hold mass curves and the structural strength of transverse corrugated bulkheads and double bottoms of new and existing bulk carriers to which these requirements apply.

1.5 RUDDER

1.5.1 The RUDDER programme performs the rule checks of rudders. In particular, it allows to calculate and verify the compliance with the rules of:

- the geometric characteristics of the rudder blade
- the scantlings of rudder stock, rudder blade, pintles and bearings
- the geometric characteristics and the scantlings of rudder horns and sole piece cross-sections.

Part B
Hull and Stability

Chapter 2
GENERAL ARRANGEMENT DESIGN

Symbols used in this Chapter

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

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

SECTION 1 SUBDIVISION ARRANGEMENT

1 General

1.1 Application to ships having additional service feature SPxxx

1.1.1 Ships having additional service feature **SPxxx** with xxx equal to or greater than 240 are to comply, in addition to the applicable requirements of this Section, with the requirements of Pt D, Ch 11, Sec 2, considering the special personnel as passengers.

1.1.2 Ships having additional service feature **SPxxx** with xxx less than 240 are to comply with the requirements of this Section, unless otherwise specified, considering the special personnel as crew.

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 transverse watertight bulkheads:

- one collision bulkhead
- one after peak bulkhead for **passenger ships** and **ro-ro passenger ships**
- 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

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

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

Table 1 : Number of bulkheads

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

2.2 Water ingress detection

2.2.1 A water ingress detection system is to be fitted according to Pt C, Ch 1, Sec 10, [6.12].

3 Collision bulkhead

3.1

3.1.1 *A 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 from the forward perpendicular* FP_{LL} *of not less than 5 per cent of the length* L_{LL} *of the ship or 10 m, whichever is the less, and, except as may be permitted by the Society, not more than 8 per cent of* L_{LL} *or 5 per cent of the* L_{LL} *+ 3 m, whichever is the greater.*

For ships not covered by the SOLAS Convention, the length L_{LL} need not be taken less than 50 m, unless required by the National Authorities.

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

- *at the mid-length of such extension, or*
- *at a distance 1,5 per cent of the length* L_{LL} *of the ship forward of the forward perpendicular, or*
- *at a distance 3 metres 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 the collision bulkhead below the bulkhead deck.

3.1.4 At Owner request and subject to the agreement of the flag Administration, the Society may, on a case by case basis, accept a distance from the collision bulkhead to the forward perpendicular FP_{LL} 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 summer waterline, flooding of the space forward of the collision bulkhead will not result in any part of the freeboard deck becoming submerged, or in any unacceptable loss of stability.

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

3.1.5 *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] with the exemption permitted by [3.1.6] and the part of the deck which forms the step is made effectively weathertight.*

3.1.6 *Where bow doors are fitted and a sloping loading ramp forms part of the extension of the collision bulkhead above the freeboard deck, the part of the ramp which is more than 2,3 m above the freeboard deck may extend forward of the limit specified in [3.1.1] or [3.1.2] The ramp is to be weathertight over its complete length.*

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

4 After peak, machinery space bulkheads and stern tubes

4.1

4.1.1 General

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

4.1.2 Sterntubes

In all cases, sterntubes are to be enclosed in watertight spaces of moderate volume. In passenger ships, the stern gland is to be situated in a watertight shaft tunnel or other watertight space separate from the sterntube compartment and of such volume that, if flooded by leakage through the stern gland, the bulkhead deck will not be immersed. In cargo ships, other measures to minimise the danger of water penetrating into the ship in case of damage to sterntube arrangements may be taken at the discretion of the Society.

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

5 Height of transverse watertight bulkheads other than collision bulkhead and after peak bulkhead

5.1

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

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

6 Openings in watertight bulkheads and decks for ships having a service notation other than passenger ship or ro-ro passenger ship

6.1 Application

6.1.1 The requirements in [6.2] and [6.3] apply to ships having a service notation other than **passenger ship** or **ro-ro passenger ship**.

Openings in watertight bulkheads below the bulkhead deck for ships with service notation **passenger ship** or **ro-ro passenger ship** are to comply with Part D, Chapter 11 or Part D, Chapter 12, respectively.

6.1.2 The requirements in [6.2] and [6.3] are not applicable to ships having additional service feature **SPxxx** with xxx less than 240.

Openings in watertight bulkheads below the bulkhead deck for ships with additional service feature **SPxxx** with xxx less than 240 are to comply with Part D, Chapter 11.

6.2 General

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

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

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

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

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

6.3 Openings in the watertight bulkheads and internal decks

6.3.1 Openings used while at sea

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

6.3.2 Openings normally closed at sea

Access doors and access hatch covers normally closed at sea, intended to ensure the watertight integrity of internal openings, are to be provided with means of indication locally and on the bridge showing whether these doors or hatch covers are open or closed. A notice is to be affixed to each such door or hatch cover to the effect that it is not to be left open.

6.3.3 Doors or ramps in large cargo spaces

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

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

6.3.4 Openings permanently kept closed at sea

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

Table 2 : Doors

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

(1) Watertight doors are required when they are located below the waterline at the equilibrium of the final stage of flooding; otherwise a weathertight door is accepted.
(2) Notice to be affixed on both sides of the door: “to be kept closed at sea”.
(3) Type A ships of 150 m and upwards, and Type B ships with a reduced freeboard may have a hinged watertight door between the engine room and the steering gear space, provided that the sill of this door is above the summer load waterline.
(4) The door is to be closed before the voyage commences.
(5) If the door is accessible during the voyage, a device which prevents unauthorised opening is to be fitted.

SECTION 2 COMPARTMENT ARRANGEMENT

1 General

1.1 Application to ships having additional service feature SPxxx

1.1.1 Ships having additional service feature **SPxxx** with xxx equal to or greater than 240 are to comply, in addition of the applicable requirements of this Section with the requirements of Pt D, Ch 11, Sec 2, considering the special personnel as passengers.

1.1.2 Ships having additional service feature **SPxxx** with xxx less than 240 are to comply with the requirements of this Section, unless otherwise specified, considering the special personnel as crew.

1.2 Definitions

1.2.1 Cofferdam

A cofferdam means an empty space arranged so that compartments on each side have no common boundary; a cofferdam may be located vertically or horizontally. As a rule, a cofferdam is to be properly ventilated and of sufficient size to allow for inspection.

1.2.2 Machinery spaces of category A

Machinery spaces of category A are those spaces or trunks to such spaces which contain:

- *internal combustion machinery used for main propulsion; or*
- *internal combustion machinery used for purposes other than propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or*
- *any oil fired boiler or fuel oil unit.*

2 Cofferdams

2.1 Cofferdam arrangement

2.1.1 Cofferdams are to be provided between:

- fuel oil tanks and lubricating oil tanks
- compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and compartments intended for fresh water (drinking water, water for propelling machinery and boilers)
- compartments intended for liquid hydrocarbons (fuel oil, lubricating oil) and tanks intended for the carriage of liquid foam for fire extinguishing.

2.1.2 Cofferdams separating:

- fuel oil tanks from lubricating oil tanks
- lubricating oil tanks from compartments intended for fresh water or boiler feed water
- lubricating oil tanks from those intended for the carriage of liquid foam for fire extinguishing

may not be required when deemed impracticable or unreasonable by the Society in relation to the characteristics and dimensions of the spaces containing such tanks, provided that:

- the thickness of common boundary plates of adjacent tanks is increased, with respect to the thickness obtained according to Ch 7, Sec 1, by 2 mm in the case of tanks carrying fresh water or boiler feed water, and by 1 mm in all other cases
- the sum of the throats of the weld fillets at the edges of these plates is not less than the thickness of the plates themselves
- the structural test is carried out with a head increased by 1 m with respect to Ch 11, Sec 3, [1.4].

2.1.3 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 recognized as suitable by the Society.

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

2.1.4 Vented cofferdam may be required to separate heated oil fuel tanks from enclosed spaces located directly above (see Pt C, Ch 1, Sec 10, [11.7.2], item a)).

3 Double bottoms

3.1 Double bottom arrangement for ships other than tankers

3.1.1 *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.*

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

$h = B/20$

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

3.1.3 *Small wells constructed in the double bottom, in connection with the drainage arrangements of holds, are not to extend downward more than necessary. A well extending to the outer bottom, is, however, permitted at the after end of the shaft tunnel of the ship. Other wells may be permitted by the Society if it is satisfied that the arrangements give protection equivalent to that afforded by a double bottom complying with [3.1]. In no case, the vertical distance from the bottom of such a well to a plane coinciding with the keel line is to be less than 500 mm.*

3.1.4 *A double bottom need not be fitted in way of watertight tanks, including dry tanks of moderate size, provided the safety of the ship is not impaired in the event of bottom or side damage as defined in Ch 3, Sec 3, [3.4].*

3.1.5 *Any part of a ship that is not fitted with a double bottom in accordance with [3.1.1] or [3.1.4] is to be capable of withstanding bottom damages, as specified in Ch 3, Sec 3, [3.4], in that part of the ship.*

3.1.6 *In the case of unusual bottom arrangements, it is to be demonstrated that the ship is capable of withstanding bottom damages as specified in Ch 3, Sec 3, [3.4].*

3.1.7 Special requirements for passenger ships and tankers are specified in Part D.

4 Compartments forward of the collision bulkhead

4.1 General

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

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

5 Minimum bow height

5.1 General

5.1.1 *The bow height F_b defined as the vertical distance at the forward perpendicular between the waterline corresponding to the assigned summer freeboard and the designed trim and the top of the exposed deck at side, is to be not less than:*

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

where:

- F_b : *Calculated minimum bow height, in mm*
- T_1 : *Draught at 85% of the least moulded depth, in m, as defined in Ch 1, Sec 2, [3.2.3]*
- C_{wf} : *Waterplane area coefficient forward of $L_{LL}/2$:*

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

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

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

5.1.2 *Where the bow height required in [5.1.1] is obtained by sheer, the sheer is to extend for at least 15% of L_{LL} of the ship measured from the forward perpendicular. Where it is obtained by fitting a superstructure, such superstructure is to extend from the stem to a point at least $0{,}07L_{LL}$ abaft the forward perpendicular and is to be enclosed as defined in Ch 8, Sec 4.*

5.1.3 *Ships which, to suit exceptional operational requirements, cannot meet the requirements in [5.1.1] and [5.1.2] will be considered by the Society on a case by case basis.*

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

5.1.5 *Where the forecastle height is less than one half of the standard height of superstructure, the credited bow height may be determined as follows:*

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

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

- Z_b, Z_t : *As defined in Fig 1*
- h_f : *Half standard height of superstructure.*

b) *Where the freeboard deck has sheer extending for less than $0{,}15L_{LL}$ or has no sheer, by a line from the forecastle deck at side at $0{,}07L_{LL}$ extended parallel to the base line to the forward perpendicular (see Fig 2).*

Figure 1 : Credited bow height where the freeboard deck has sheer extending from abaft 0,15 L

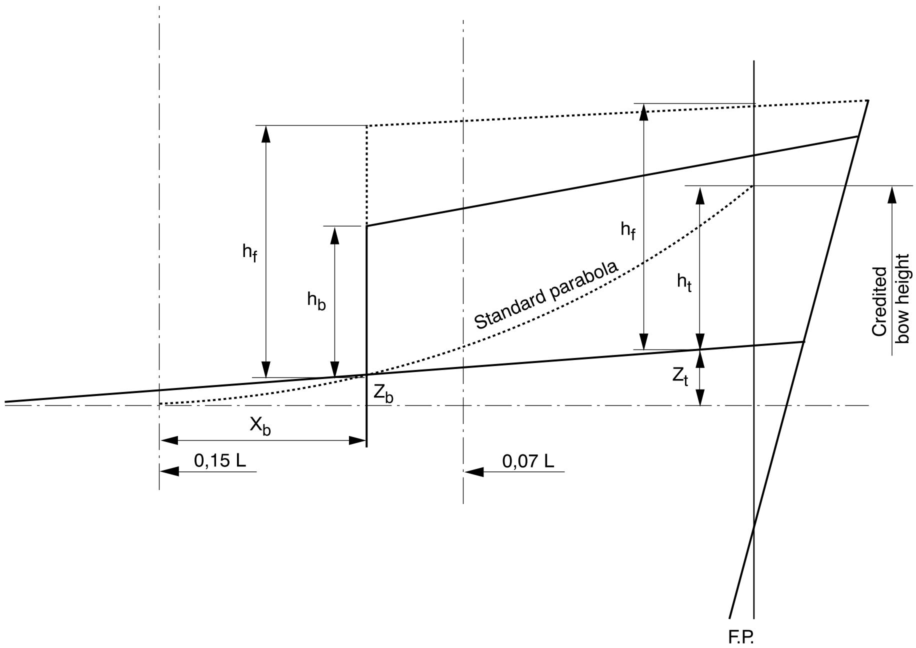
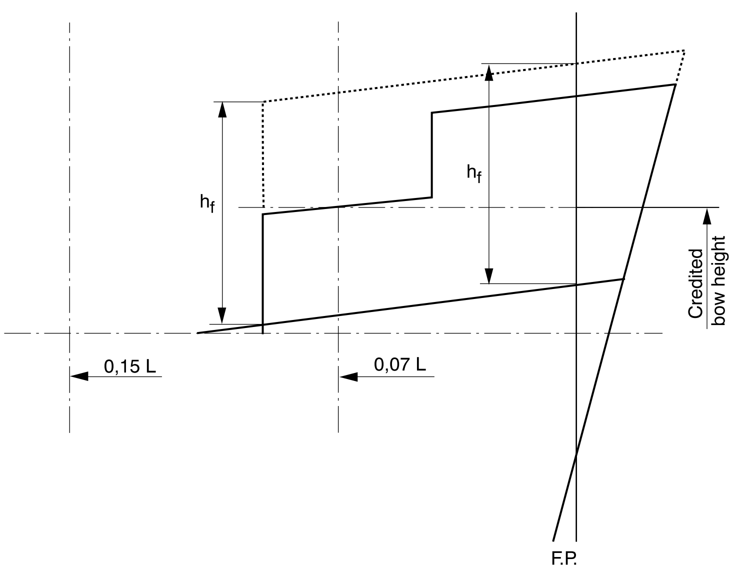


Figure 2 : Credited bow height where the freeboard deck has sheer extending for less than 0,15 L



5.1.6 *All ships assigned a type B freeboard, other than oil tankers, chemical tankers and gas carriers, are to have additional reserve buoyancy in the fore end. Within the range of $0,15L_{LL}$ abaft of the forward perpendicular, the sum of the projected area between the summer load waterline and the deck at side (A1 and A2 in Fig 3) and the projected area of an enclosed superstructure, if fitted, is, in m^2, to be not less than:*

$$A3 = (0,15\ F_{min} + 4\ (L_{LL}/3 + 10))\ L_{LL}/1000$$

where:

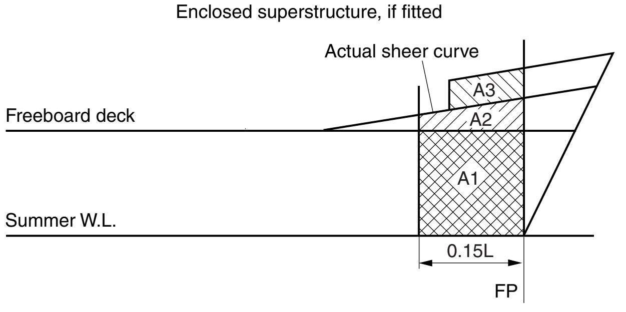
F_{min} : $F_{min} = (F_0 \cdot f_1) + f_2$

F_0 : *Tabular freeboard, in mm, taken from the International Convention on Load Lines, as amended, Table 28.2, corrected for regulation 27(9) or 27(10), as applicable*

f_1 : *Correction for block coefficient given in the International Convention on Load Lines, as amended, regulation 30*

f_2 : *Correction for depth, in mm, given in the International Convention on Load Lines, as amended, regulation 31.*

Figure 3 : Areas A1, A2 and A3



6 Shaft tunnels

6.1 General

6.1.1 Shaft tunnels are to be watertight.

See also Ch 8, Sec 2.

7 Watertight ventilators and trunks

7.1 General

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

8 Fuel oil tanks

8.1 General

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

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

Where fuel oil tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of category A, at least one of their vertical sides is to be contiguous to the machinery space boundaries, they are preferably to have a common boundary with the double bottom tanks and the area of the tank boundary common with the machinery spaces is to be kept to a minimum.

Where such tanks are situated within the boundaries of machinery spaces of category A, they may not contain fuel oil having a flashpoint of less than 60°C.

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

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

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

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

8.2 Fuel oil tank protection

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

SECTION 3 ACCESS ARRANGEMENT

1 General

1.1

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

2 Double bottom

2.1 Inner bottom manholes

2.1.1 Inner bottom manholes are to be not less than 400 mm x 400 mm. Their number and location are to be so arranged as to provide convenient access to any part of the double bottom.

2.1.2 Inner bottom manholes are to be closed by watertight plate covers.

Doubling plates are to be fitted on the covers, where secured by bolts.

Where no ceiling is fitted, covers are to be adequately protected from damage by the cargo.

2.2 Floor and girder manholes

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

2.2.2 The size of manholes and lightening holes in floors and girders is, in general, to be less than 50 per cent of the local height of the double bottom.

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

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

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

3.1 General

3.1.1 The requirements in [3.2] to [3.4] are not applicable to ships with service notations **bulk carrier**, **bulk carrier CSR ESP**, **bulk carrier CSR BC-A ESP**, **bulk carrier CSR BC-B ESP**, **bulk carrier CSR BC-C ESP**, **ore carrier ESP**, **combination carrier ESP**, of 20,000 gross tonnage and over, and to ships with service notation **oil tanker ESP** of 500 gross tonnage and over. For such ships, refer to the applicable requirements of Part D.

3.1.2 The requirements in [3.2] to [3.4] are not applicable to spaces in double bottom and double side tanks.

3.2 Access to tanks

3.2.1 Tanks with a length equal to or greater than 35 m

Tanks and subdivisions of tanks having lengths of 35 m and above are to be fitted with at least two access hatchways and ladders, as far apart as practicable longitudinally.

3.2.2 Tanks with a length less than 35 m

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

3.2.3 Dimensions of access hatchways

The dimensions of any access hatchway are to be sufficient to allow a person wearing a self-contained breathing apparatus to ascend or descend the ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the tank. In no case is the clear opening to be less than 600 mm x 600 mm.

3.2.4 Tanks subdivided by wash bulkheads

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

3.3 Access within tanks

3.3.1 Wash bulkheads in tanks

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

3.3.2 Passage on the tank bottom

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

3.3.3 Passageways in the tanks

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

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

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

3.3.4 Manholes

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

3.3.5 Guard rails

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

3.4 Construction of ladders

3.4.1 General

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

3.4.2 Construction

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

3.4.3 Corrosive effect of the cargo

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

3.4.4 Width of ladders

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

3.4.5 Treads

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

3.4.6 Sloping ladders

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

4 Shaft tunnels

4.1 General

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

4.1.2 Access to the tunnel is to be provided by a watertight door fitted on the aft bulkhead of the engine room in compliance with Ch 2, Sec 1, [6], and an escape trunk which can also act as watertight ventilator is to be fitted up to the subdivision deck, for tunnels greater than 7 m in length.

5 Access to steering gear compartment

5.1

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

5.1.2 Suitable arrangements to ensure working access to steering gear machinery and controls are to be provided.

These arrangements are to include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

Part B
Hull and Stability

Chapter 3
STABILITY

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 General

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

1.1.2 Ships less than 24 m in length

The Rules also apply to ships less than 24 m in length. In this case, the requirements concerned may be partially omitted when deemed appropriate by the Society.

1.1.3 Approval of the Administration

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

1.2 Application to ships having additional service feature SPxxx

1.2.1 Ships having additional service feature **SPxxx** with xxx equal to or greater than 240 are to comply, in addition to the applicable requirements of this Chapter, with the requirements of Pt D, Ch 11, Sec 3, considering the special personnel as passengers.

1.2.2 Ships having additional service feature **SPxxx** with xxx less than 240 are to comply with the requirements of this Chapter, unless otherwise specified, considering the special personnel as crew.

2 Examination procedure

2.1 Documents to be submitted

2.1.1 List of documents

For the purpose of the examination of the stability, the 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, [1.2.1], is as follows:

- Inclining test report for the ship, as required in [2.2] or:
  - where the stability data is based on a sister ship, the inclining test report of that sister ship along with the lightship measurement report for the ship in question; or
  - where lightship particulars are determined by methods other than inclining of the ship or its sister, the lightship measurement report of the ship along with a summary of the method used to determine those particulars as indicated in [2.2.4].
- trim and stability booklet, as required in Ch 3, Sec 2, [1.1.1]
- and, as applicable:
  - grain loading manual, as required in Pt D, Ch 4, Sec 3, [1.2.2]
  - damage stability calculations, as required in Ch 3, Sec 3, [3.1]
  - damage control documentation, as required in Ch 3, Sec 3, [4]
  - loading computer documentation, as required in Ch 3, Sec 2, [1.1.2] and in Ch 3, Sec 3, [3.1.3].

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

2.1.2 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.

2.1.3 Final documentation

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

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

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

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

2.2 Inclining test/lightweight check

2.2.1 Definitions

a) Lightship

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

b) Inclining test

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

c) Lightweight check

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

2.2.2 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. Cases for which the inclining test is required and those for which the lightweight check is accepted in its place are listed in [2.2.4] and [2.2.5].

A detailed procedure of the test is to be submitted to the Society prior to the test. This procedure is to include:

a) identification of the ship by name and shipyard hull number, if applicable

b) date, time and location of the test

c) inclining weight data:

- *type*
- *amount (number of units and weight of each)*
- *certification*
- *method of handling (i.e. sliding rail or crane)*
- *anticipated maximum angle of heel to each side*

d) measuring devices:

- *pendulums - approximate location and length*
- *U-tubes - approximate location and length*
- *inclinometers - Location and details of approvals and calibrations*

e) approximate trim

f) condition of tanks

g) estimate weights to deduct, to complete, and to relocate in order to place the ship in its true lightship condition.

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

The inclining test is adaptable to ships less than 24 m in length, provided that precautions are taken, on a case by case basis, to ensure the accuracy of the test procedure.

2.2.3 Inclining test

The inclining test is required in the following cases:

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

Note 1: Due attention is to be paid to SOLAS Ch.II.1 Reg.22 (if applicable) whereby it is stipulated that such allowance is subject to the Flag Authorities agreement (refer to Pt A, Ch 1, Sec 1, [3.1.1]).

2.2.4 Lightweight check

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

- *stability data are available from the inclining test of a sister ship and it is shown to the satisfaction of the Society that reliable stability information for the exempted ship can be obtained from such basic data. A weight survey shall be carried out upon completion and the ship shall be inclined whenever in comparison with the data derived from the sister ship, a deviation from the lightship displacement exceeding 1% for ships of 160 m or more in length and 2% for ships of 50 m or less in length and as determined by linear interpolation for intermediate lengths or a deviation from the lightship longitudinal centre of gravity exceeding 0.5% of L_S is found.*
- special types of ship, such as pontoons, provided that the vertical centre of gravity is considered at the level of the deck.
- special types of ship provided that:
  - a detailed list of weights and the positions of their centres of gravity is submitted
  - a lightweight check is carried out, showing accordance between the estimated values and those determined
  - adequate stability is demonstrated in all the loading conditions reported in the trim and stability booklet.

2.2.5 Detailed procedure

A detailed procedure for conducting an inclining test is included in Ch 3, App 1. For the lightweight check, the same procedure applies except as provided for in Ch 3, App 1, [1.1.9].

SECTION 2 INTACT STABILITY

1 General

1.1 Information for the Master

1.1.1 Stability booklet

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.

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

Stability data and associated plans are to be drawn up in the working language of the ship and any other language the Society may require. reference is also made to the International Safety Management (ISM) Code, adopted by IMO by resolution A.741(18). All translations of the stability booklet are to be approved.

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

1.1.2 Loading instrument

As a supplement to the approved stability booklet, a loading instrument, approved by the Society, may be used to facilitate the stability calculations mentioned in Ch 3, 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].

1.1.3 Operating booklets for certain ships

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

1.2 Permanent ballast

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

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

2 Design criteria

2.1 General intact stability criteria

2.1.1 General

The intact stability criteria specified in [2.1.2], [2.1.3], [2.1.4],and [2.1.5] are to be complied with for the loading conditions mentioned in Ch 3, App 2, [1.2].

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

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

2.1.2 GZ curve area

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

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

The means of closing air pipes are to be weathertight and of an automatic type if the openings of the air pipes to which the devices are fitted would be submerged at an angle of less than 40 degrees (or any lesser angle which may be needed to suit stability requirements) when the ship is floating at its summer load line draught. Pressure/vacuum valves (P.V. valves) may be accepted on tankers. Wooden plugs and trailing canvas hoses may not be accepted in positions 1 and 2 as defined in Ch 1, Sec 2, [3.22].

2.1.3 Minimum righting lever

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

2.1.4 Angle of maximum righting lever

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

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

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

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

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

2.1.5 Initial metacentric height

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

2.1.6 Elements affecting stability

A number of influences such as beam wind on ships with large windage area, icing of topsides, water trapped on deck, rolling characteristics, following seas, etc., which adversely affect stability, are to be taken into account.

2.1.7 Elements reducing stability

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

3 Severe wind and rolling criterion (weather criterion)

3.1 Scope

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

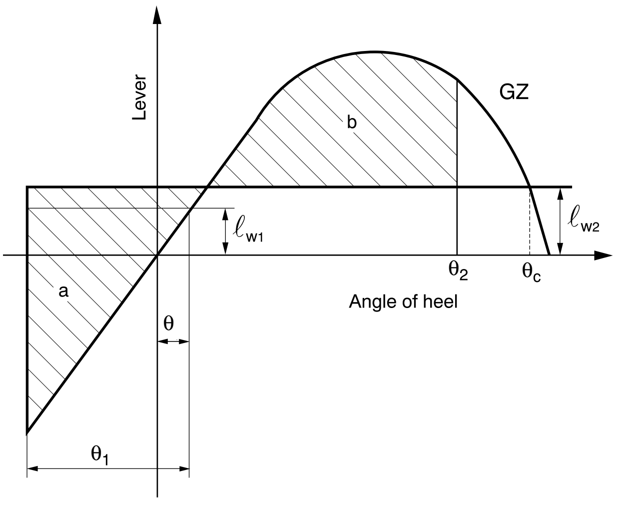
3.2 Weather criterion

3.2.1 Assumptions

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

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

Figure 1 : Severe wind and rolling



3.2.2 Criteria

Under the assumptions of [3.2.1], the following criteria are to be complied with:

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

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

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

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

3.2.3 Heeling levers

The wind heeling levers ℓ_{w1} and ℓ_{w2}, in m, referred to in [3.2.2], are constant values at all angles of inclination and are to be calculated as follows:

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

and

$$\ell_{W2} = 1{,}5\,\ell_{W1}$$

where:

P : 504 N/m² for unrestricted navigation notation. The value of P used for ships with restricted navigation notation may be reduced subject to the approval of the Society

A : Projected lateral area in m², of the portion of the ship and deck cargo above the waterline

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

Δ : Displacement in t

$g = 9{,}81$ m/s².

3.2.4 Angles of heel

For the purpose of calculating the criteria of [3.2.2], the angles in Fig 1 are defined as follows:

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

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

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

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

θ_f : *Angle of heel in degrees, at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open*

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

$\theta_R = \theta_0 - \theta_1$

X_1 : *Coefficient defined in Tab 1*

X_2 : *Coefficient defined in Tab 2*

k : *Coefficient equal to:*

k = 1,0 for a round-bilged ship having no bilge or bar keels

k = 0,7 for a ship having sharp bilge

For a ship having bilge keels, a bar keel or both, k is defined in Tab 3.

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

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

T_1 : *Mean moulded draught in m, of the ship*

s : *Factor defined in Tab 4.*

Note 1: The angle of roll θ_1 for ships with anti-rolling devices is to be determined without taking into account the operations of these devices.

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

The rolling period T_R, in s, is calculated as follows:

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

where:

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

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

L_W : *Length in m, of the ship at the waterline*

T_1 : *Mean moulded draught in m, of the ship*

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

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

Table 1 : Values of coefficient X_1

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

Table 2 : Values of coefficient X_2

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

Table 3 : Values of coefficient k

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

Table 4 : Values of factor s

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

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

3.2.5 *Tab 1 to Tab 4 and formulae described in [3.2.4] are based on data from ships having:*

- *B/T_1 smaller than 3,5*
- *(KG/T_1-1) between − 0,3 and 0,5*
- *T_R smaller than 20 s.*

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

3.2.6 *Alternative means for determining the wind heeling lever (ℓ_{W1}) may be accepted, to the satisfaction of the Society as an equivalent to the calculation in [3.2.3]. When such alternative tests are carried out, reference shall be made based on the Interim Guidelines for alternative assessment of the weather criterion (IMO MSC.1/Circ.1200). the wind velocity used in the tests shall be 26 m/s in full scale with uniform velocity profile. the value of wind velocity used for ships in restricted services may be reduced to the satisfaction of the Society.*

4 Effects of free surfaces of liquids in tanks

4.1 General

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

4.2 Consideration of free surface effects

4.2.1 *Free surface effects are to be considered whenever the filling level in a tank is less than 98% of full condition. Free surface effects need not be considered where a tank is nominally full, i.e. filling level is 98% or above. Free surface effects for small tanks may be ignored under the condition in [4.8.1].*

4.2.2 *Nominally full cargo tanks should be corrected for free surface effects at 98% filling level. In doing so, the correction to initial metacentric height should be based on the inertia moment of liquid surface at 5° of the heeling angle divided by displacement, and the correction to righting lever is suggested to be on the basis of real shifting moment of cargo liquids.*

4.3 Categories of tanks

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

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

4.4 Consumable liquids

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

4.5 Water ballast tanks

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

4.6 Liquid transfer operations

4.6.1 *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.*

4.7 GM_0 and GZ curve corrections

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

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

4.7.3 *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; corrections may be calculated according to the categories indicated in [4.3.1]*
- *correction based on the moment of inertia, calculated at 0 degrees angle of heel, modified at each angle of heel calculated; corrections may be calculated according to the categories indicated in [4.3.1].*

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

4.8 Small tanks

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

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

where:

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

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

4.9 Remainder of liquid

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

5 Cargo ships carrying timber deck cargoes

5.1 Application

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

5.2 Definitions

5.2.1 Timber

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

5.2.2 Timber deck cargo

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

5.2.3 Timber load line

Timber load line means a special load line assigned to ships complying with certain conditions related to their construction set out in the International Convention on Load Lines 1966, as amended, and used when the cargo complies with the stowage and securing conditions of the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991 (Resolution A.715(17)).

5.3 Stability criteria

5.3.1 *For ships loaded with timber deck cargoes and provided that the cargo extends longitudinally between superstructures (where there is no limiting superstructure at the after end, the timber deck cargo is to extend at least to the after end of the aftermost hatchway) and transversely for the full beam of ship after due allowance for a rounded gunwale not exceeding 4% of the breadth of the ship and/or securing the supporting uprights and which remains securely fixed at large angles of heel, the Society may apply the* criteria given in [5.3.2] to [5.3.5], *which substitute those given in [2.1.2], [2.1.3], [2.1.4] and [2.1.5] and in [3.2].*

5.3.2 *The area under the righting lever curve (GZ curve) is to be not less than 0,08 m·rad up to θ = 40° or the angle of flooding if this angle is less than 40°.*

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

5.3.4 *At all times during a voyage, the metacentric height GM_0 is to be not less than 0,10 m after correction for the free surface effects of liquid in tanks and, where appropriate, the absorption of water by the deck cargo and/or ice accretion on the exposed surfaces. (Details regarding ice accretion are given in [6]). Additionally, in the departure condition the metacentric height is to be not less than 0,10 m.*

5.3.5 *When determining the ability of the ship to withstand the combined effect of beam wind and rolling according to [3.2], the 16° limiting angle of heel under action of steady wind is to be complied with, but the additional criterion of 80% of the angle of deck edge immersion may be ignored.*

5.4 Stability booklet

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

5.4.2 *For ships carrying timber deck cargoes, the Society may deem it necessary that the Master be given information setting out the changes in deck cargo from that shown in the loading conditions, when the permeability of the deck cargo is significantly different from 25% (see [5.5.1]).*

5.4.3 *For ships carrying timber deck cargoes, conditions are to be shown indicating the maximum permissible amount of deck cargo having regard to the lightest stowage rate likely to be met in service.*

5.5 Calculation of the stability curve

5.5.1 *In addition to the provisions given in Ch 3, App 2, [1.3], the Society may allow account to be taken of the buoyancy of the deck cargo assuming that such cargo has a permeability of 25% of the volume occupied by the cargo. Additional curves of stability may be required if the Society considers it necessary to investigate the influence of different permeabilities and/or assumed effective height of the deck cargo.*

5.6 Loading conditions to be considered

5.6.1 *The loading conditions which are to be considered for ships carrying timber deck cargoes are specified in Ch 3, App 2, [1.2.2]. For the purpose of these loading conditions, the ship is assumed to be loaded to the summer timber load line with water ballast tanks empty.*

5.7 Assumptions for calculating loading conditions

5.7.1 *The following assumptions are to be made for calculating the loading conditions referred to in Ch 3, App 2, [1.2.2]:*

- *the amount of cargo and ballast is to correspond to the worst service condition in which all the relevant stability criteria reported in [2.1.2], [2.1.3], [2.1.4] and [2.1.5], or the optional criteria given in [5.3], are met*
- *in the arrival condition, it is to be assumed that the weight of the deck cargo has increased by 10% due to water absorption.*

5.7.2 *The stability of the ship at all times, including during the process of loading and unloading timber deck cargo, is to be positive and* in compliance with the stability criteria of [5.3]. *It is to be calculated having regard to:*

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

5.7.3 *Excessive initial stability is to be avoided as it will result in rapid and violent motion in heavy seas which will impose large sliding and racking forces on the cargo causing high stresses on the lashings.* Unless otherwise stated in the stability booklet, *the metacentric height is* generally *not to exceed 3% of the breadth in order to prevent excessive acceleration in rolling provided that the relevant stability criteria given in [5.3] are satisfied.*

5.8 Stowage of timber deck cargoes

5.8.1 *The stowage of timber deck cargoes is to comply with the provisions of chapter 3 of the Code of Safe Practice for Ships Carrying Timber Deck Cargoes, 1991 (resolution A.715(17)).*

6 Icing

6.1 Application

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

6.2 Ships carrying timber deck cargoes

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

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

6.3 Calculation assumptions

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

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

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

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

6.4 Guidance relating to ice accretion

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

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

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

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

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

e) *south of latitude 60°S.*

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

- *within the areas defined in a), c), d) and e)* of [6.4.1] *known to having icing conditions significantly different from those described in [6.3], ice accretion requirements of one half to twice the required allowance may be applied*
- *within the area defined in b), where ice accretion in excess of twice the allowance required by [6.3] may be expected, more severe requirements than those given in [6.3] may be applied.*

SECTION 3 DAMAGE STABILITY

1 Application

1.1 Ships for which damage stability is required

1.1.1 Damage stability calculation is required for ships which have been requested to receive **SDS** additional class notation.

1.2 Ships having additional class notation SDS and additional service feature SPxxx

1.2.1 Ships having additional class notation **SDS** and additional service feature **SPxxx** are to comply, in addition to the applicable requirements of this Section, with the requirements of Pt D, Ch 11, Sec 3, [1.3], considering the special personnel as passengers, where the attained subdivision index A (defined in Pt D, Ch 11, Sec 3, [1.3.3]) is not to be less than:

- R, where the ship is carrying 240 persons or more,
- 0.8 R, where the ship is carrying not more than 60 persons,
- R value to be calculated by linear interpolation between 0.8 R and R, where the ship is carrying more than 60 (but not more than 240) persons.

1.2.2 However, for ships having additional class notation **SDS** and additional service feature **SPxxx** with xxx less than 240 persons, Pt D, Ch 11, Sec 3, [1.3.12] is not applicable.

2 General

2.1 Approaches to be followed for damage stability investigation

2.1.1 General

Damage stability calculations are required in order to assess the attitude and stability of the ship after flooding.

In order to assess the behaviour of the ship after damage, two approaches have been developed: the deterministic and the probabilistic, which are to be applied depending on the ship type as specified in Part D.

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

2.1.2 Deterministic approach

The deterministic 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 case, depend on the ship's dimensions and internal subdivision.

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

Different deterministic methods in damage stability have been developed depending on ship type, on freeboard reduction, and on the kind of cargo carried.

The deterministic methods to be applied for passenger ships, oil tankers, chemical tankers, gas carriers and special purpose ships are reported in the relevant chapters of Part D.

The deterministic methods to be applied in the case of freeboard reduction are specified in Ch 3, App 4.

2.1.3 Probabilistic approach

The probabilistic concept takes the probability of survival after collision as a measure of ship safety in the damaged condition, referred to as the attained subdivision index A.

The damage stability calculations are performed for a limited number of draughts and relevant GM values in order to draw a minimum GM curve where the attained subdivision index A achieves the minimum required level of safety R. For cargo ships, each case of damage is not required to comply with the applicable criteria, but the attained index A, which is the sum of the contribution of all damage cases, is to be equal to or greater than R.

The probabilistic method developed on the basis of the above-mentioned concepts is detailed in Ch 3, App 3.

As a general rule, the probabilistic method applies to cargo ships of a length not less than 80 m, and for which no deterministic methods apply; the application of the probabilistic damage stability investigation is specified in the relevant chapters of Part D.

3 Documents to be submitted

3.1 Damage stability calculations

3.1.1 Damage stability documentation

For all ships to which damage stability requirements apply, documents including damage stability calculations are to be submitted.

The damage stability calculations are to include:

- list of the characteristics (volume, centre of gravity, permeability) of each compartment which can be damaged
- 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, semi-watertight or unprotected
  - operating system: remote control, local operation, indicators on the bridge, television surveillance, water leakage detection, audible alarm, as applicable
  - foreseen utilization: open at sea, normally closed at sea, kept closed at sea
- list of all damage cases corresponding to the applicable requirements
- detailed results of damage stability calculations for all the loading conditions foreseen in the applicable requirements
- the limiting GM/KG curve, if foreseen in the applicable requirements
- capacity plan
- cross and down flooding devices and the calculations thereof according to Pt D, Ch 11, App 1 with informations about diameter, valves, pipe lengths and coordinates of inlet/outlet
- watertight and weathertight door plan with pressure calculation
- side contour and wind profile
- pipes and damaged area when the destruction of these pipes results in progressive flooding.

3.1.2 Additional information for the probabilistic approach

In addition to the information listed in [3.1.1], the following is to be provided:

- *subdivision length* L_S
- *initial draughts and the corresponding GM-values*
- *required subdivision index R*
- *attained subdivision index A with a summary table for all contributions for all damaged zones.*
- *draught, trim, GM in damaged condition*
- *damage extension and definition of damage cases with probabilistic values p, v and r*
- *righting lever curve (including GZmax and range) with factor of survivability s*
- *critical weathertight and unprotected openings with their angle of immersion*
- *details of sub-compartments with amount of in-flooded water/lost buoyancy with their centres of gravity.*

3.1.3 Loading instrument

As a supplement to the approved damage stability documentation, a loading instrument, approved by the Society, may be used to facilitate the damage stability calculations mentioned in [3.1.1].

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, [4.7].

3.2 Permeabilities

3.2.1 Definition

The permeability of a space means the ratio of the volume within that space which is assumed to be occupied by water to the total volume of that space.

3.2.2 General

The permeabilities relevant to the type of spaces which can be flooded depend on the applicable requirements. Such permeabilities are indicated in Part D for each type of ship.

3.3 Progressive flooding

3.3.1 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 [3.3.2] and [3.3.3].

3.3.2 Openings

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

- Unprotected

  Unprotected openings may lead to progressive flooding if they are situated within the range of the positive righting lever curve or if they are located below the waterline after damage (at any stage of flooding). Unprotected openings are openings which are not fitted with at least weathertight means of closure.
- 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 waterline after damage (at any stage of flooding).
- Semi-watertight

  Internal openings fitted with semi-watertight means of closure are able to sustain a constant head of water corresponding to the immersion relevant to the highest waterline after damage at the equilibrium of the intermediate stages of flooding.

  Semi-watertight openings may lead to progressive flooding if they are located below the final equilibrium waterline after damage.

Table 1 : Assumed extent of damage

	For 0,3 L from the forward perpendicular of the ship	Any other part of the ship
Longitudinal extent	1/3 $L^{2/3}$ or 14,5 m, whichever is less	1/3 $L^{2/3}$ or 14,5 m, whichever is less
Transverse extent	B/6 or 10 m, whichever is less	B/6 or 5 m, whichever is less
Vertical extent, measured from the keel line	B/20 or 2 m, whichever is less	B/20 or 2 m, whichever is less

- 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/freeboard deck.

  Air pipe closing devices complying with Pt C, Ch 1, Sec 10, [9.1.6] 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 tanks may be considered watertight.

  Watertight openings do not lead to progressive flooding.

3.3.3 Pipes

Progressive flooding through pipes may occur when:

- the pipes and connected valves are located within the assumed damage, and no valves are fitted outside the damage
- 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 systems are fitted to ballast valves and these controls pass through the assumed extent 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. However, the Society may permit minor progressive flooding if it is demonstrated that the additional flooding of those compartments cannot lead to the capsizing or the sinking of the ship.

Requirements relative to the prevention of progressive flooding are specified in Pt C, Ch 1, Sec 10, [5.5].

3.4 Bottom damages

3.4.1 General

Ships which are not fitted with a double bottom as required by Ch 2, Sec 2, [3.1.2] or which are fitted with unusual bottom arrangements as defined in Ch 2, Sec 2, [3.1.6], are to comply with [3.4.2] and [3.4.3].

3.4.2 Bottom damage description

The assumed extent of damage is described in Tab 1.

If any damage of a lesser extent than the maximum damage specified in Tab 1 would result in a more severe condition, such damage should be considered.

3.4.3 Stability criteria

Compliance with the requirements of Ch 2, Sec 2, [3.1.5] or Ch 2, Sec 2, [3.1.6] is to be achieved by demonstrating that s_i , when calculated in accordance with Ch 3, App 3, [1.6], is not less than 1 for all service conditions when subject to a bottom damage assumed at any position along the ship's bottom and with an extent specified in [3.4.2] for the affected part of the ship.

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

4 Damage control documentation

4.1 General

4.1.1 Application

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 compartmentation 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 therein 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. If the languages used in the preparation of the documentation are not English or French, a translation into one of these languages is to be included.

The use of a loading instrument performing damage stability calculations may be accepted as a supplement to the damage control documentation. This instrument is to be approved by the Society according to the requirements of Ch 10, Sec 2, [4.8].

The damage control plan is required for the following ships:

- ships carrying passengers
- cargo ships of 500 GT and over.

4.1.2 Application to ships having additional service feature SPxxx

The damage control documentation of ships having additional service feature **SPxxx** is to comply with Pt D, Ch 11, Sec 3, [1.3.14].

5 Specific interpretations

5.1 Assumed damage penetration in way of sponsons

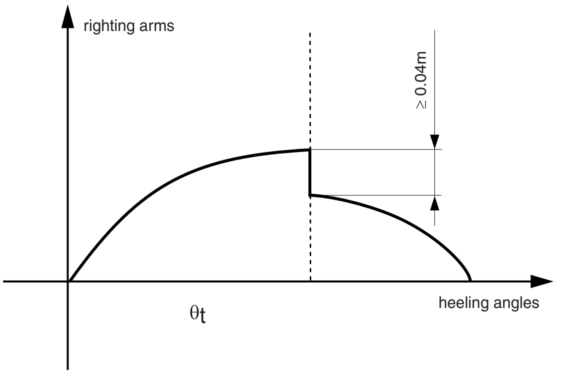
5.1.1 *If sponsons are fitted, it is necessary to establish the maximum assumed damage penetration (B/5) to be used when deciding on the various damage cases. For this purpose, the breadth B in the way of such sponsons is to be measured to the outside of the sponsons.*

Clear of any suck sponsons, the breadth B is to be the midship breadth measured to the outside of the original shell. In other words, the assumed penetration of B/5 is the same as that which applied before the fitting of sponsons.

5.2 Effect of progressive flooding on the GZ curve

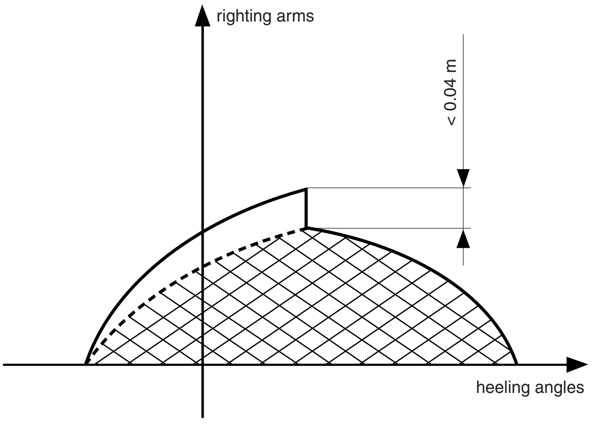
5.2.1 *When major progressive flooding occurs, that is when it causes a rapid reduction in the righting lever of 0,04 m or more, the righting lever curve is to be considered as terminated at the angle the progressive flooding occurs and the range and the area are to be measured to that angle, as shown in Fig 1.*

Figure 1 : Major progressive flooding



5.2.2 *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 2.*

Figure 2 : Progressive flooding of limited nature



APPENDIX 1 INCLINING TEST AND LIGHTWEIGHT CHECK

1 Inclining test and lightweight check

1.1 General

1.1.1 General conditions of the ship

The following conditions are to be met, as far as practicable:

- the weather conditions are to be favourable
- the ship should be moored in a quiet, sheltered area free from extraneous forces such as propeller wash from passing vessels, or sudden discharges from shore side pumps. The tide conditions and the trim of the ship during the test should be considered. Prior to the test, the depth of water should be measured and recorded in as many locations as are necessary to ensure that the ship will not contact the bottom. The specific gravity of water should be accurately recorded. The ship should be moored in a manner to allow unrestricted heeling. The access ramps should be removed. Power lines, hoses, etc., connected to shore should be at a minimum, and kept slack at all times
- the ship should be as upright as possible; with inclining weights in the initial position, up to one-half degree of list is acceptable. The actual trim and deflection of keel, if practical, should 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 should be checked beforehand
- 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
- the anticipated liquid loading for the test should be included in the planning for the test. Preferably, all tanks should be empty and clean, or completely full. The number of slack tanks should be kept to an absolute minimum. The viscosity of the fluid, the depth of the fluid and the shape of the tank should be such that the free surface effect can be accurately determined
- 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 incline 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
- decks should be free of water. Water trapped on deck may shift and pocket in a fashion similar to liquids in a tank. Any rain, snow or ice accumulated on the ship should be removed prior to the test.

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 weight. Re-certification of the test weights is to be carried out prior to the incline. A crane of sufficient capacity and reach, or some other means, is to be available during the inclining test to shift weights on the deck in an expeditious and safe manner. Water ballast transfer may be carried out, when it is impractical to incline using solid weights and subject to requirement of [1.1.3].

Weights, such as porous concrete, that can absorb significant amounts of moisture should only be used if they are weighed just prior to the inclining test or if recent weight certificates are presented. Each weight should be marked with an identification number and its weight. For small ships, drums completely filled with water may be used. Drums should normally be full and capped to allow accurate weight control. In such cases, the weight of the drums should be verified in the presence of a surveyor of the Society using a recently calibrated scale.

Precautions should be taken to ensure that the decks are not overloaded during weight movements. If deck strength is questionable then a structural analysis should be performed to determine if existing framing can support the weight.

Generally, the test weights should be positioned as far outboard as possible on the upper deck. The test weights should be on board and in place prior to the scheduled time of the inclining test.

1.1.3 Water ballast as inclining weight

Where the use of solid weights to produce the inclining moment is deemed 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
- 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 transverse 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

The use of three pendulums is recommended but a minimum of two are to be used to allow identification of bad readings at any one pendulum station. However, for ships of a length equal to or less than 30 m, only one pendulum can be accepted. They are each to be located in an area protected from the wind. The pendulums are to be long enough to give a measured deflection, to each side of upright, of at least 15 cm. To ensure recordings from individual instruments are kept separate, it is suggested that the pendulums be physically located as far apart as practical.

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

1.1.5 Free surface and slack tanks

The number of slack tanks should normally be limited to one port/starboard pair or one centreline tank of the following:

- fresh water reserve feed tanks
- fuel/diesel oil storage tanks
- fuel/diesel oil day tanks
- lube oil tanks
- sanitary tanks
- potable water tanks.

To avoid pocketing, slack tanks are normally to be of regular (i.e. rectangular, trapezoidal, etc.) cross section and be 20% to 80% full if they are deep tanks and 40% to 60% full if they are double-bottom tanks. These levels ensure that the rate of shifting of liquid remains constant throughout the heel angles of the inclining test. If the trim changes as the ship is inclined, then consideration are also to be given to longitudinal pocketing. Slack tanks containing liquids of sufficient viscosity to prevent free movement of the liquids, as the ship is inclined (such as bunker at low temperature), are to be avoided since the free surface cannot be calculated accurately. A free surface correction for such tanks is not to be used unless the tanks are heated to reduce viscosity. Communication between tanks are never to be allowed. Cross-connections, including those via manifolds, are to be closed. Equal liquid levels in slack tank pairs can be a warning sign of open cross connections. A bilge, ballast, and fuel oil piping plan can be referred to, when checking for cross connection closures.

1.1.6 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.

1.1.7 Documentation

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).*

1.1.8 Determination of the displacement

The operations necessary for the accurate evaluation of the displacement of the ship at the time of the inclining test, as listed below, are to be carried out:

- 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.
- normally, the total value of missing weights is not to exceed 2% and surplus weights, excluding liquid ballast, not exceed 4% of the lightship displacement. For smaller vessels, higher percentages may be allowed.

1.1.9 The incline

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

Movement No.8, a recheck of the zero point, may be omitted if a straight line plot is achieved after movement No.7. If a straight line plot is achieved after the initial zero and six weight movements, the inclining test is complete and the second check at zero may be omitted. If a straight line plot is not achieved, those weight movements that did not yield acceptable plotted points should be repeated or explained.

The weights are to be transversely 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 plot is to be run during the test to ensure that acceptable data are being obtained.

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

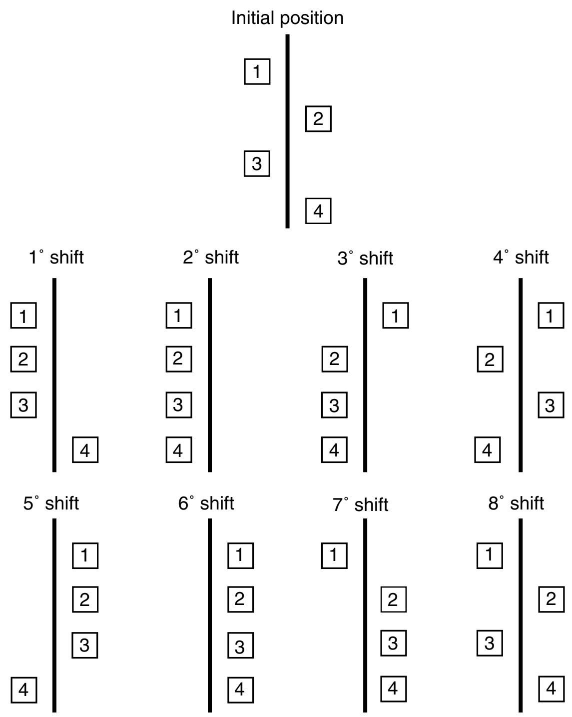
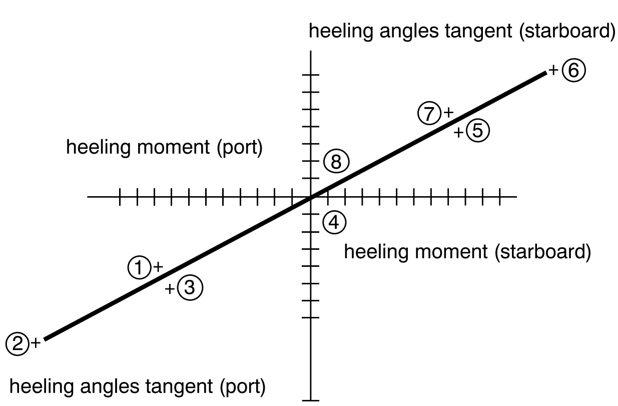


Figure 2 : Graph of resultant tangents



APPENDIX 2 TRIM AND STABILITY BOOKLET

1 Trim and stability booklet

1.1 Information to be included in the trim and stability booklet

1.1.1 General

A trim and stability booklet is a stability manual, to be approved by the Society, which is to contain 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

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

- a general description of the ship, including:
  - the ship's name and the Society classification number
  - the ship type and service notation
  - the class notations
  - the yard, the hull number and the year of delivery
  - the Flag, the port of registry, the international call sign and the IMO number
  - the moulded dimensions
  - the draught corresponding to the assigned summer load line, the draught corresponding to the assigned summer timber load line and the draught corresponding to the tropical load line, if applicable
  - the displacement corresponding to the above-mentioned draughts
- instructions on the use of the booklet
- general arrangement and capacity plans indicating the assigned use of compartments and spaces (cargo, passenger, stores, accommodation, etc.)
- a sketch indicating the position of the draught marks referred to the ship's perpendiculars
- hydrostatic curves or tables corresponding to the design trim, and, if significant trim angles are foreseen during the normal operation of the ship, curves or tables corresponding to such range of trim are to be introduced. A 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 Ch 3, Sec 1, [2.2], 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 indicated, and a copy of the approved inclining test report relevant to this sister ship is to be included
- standard loading conditions as indicated in [1.2] and examples for developing other acceptable loading conditions using the information contained in the booklet
- intact stability results (total displacement and its centre of gravity co-ordinates, draughts at perpendiculars, GM, GM corrected for free surfaces effect, GZ values and curve, criteria as indicated in Ch 3, Sec 2, [2] and Ch 3, Sec 2, [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 [1.3]
- information on loading restrictions (maximum allowable load on double bottom, maximum specific gravity allowed in liquid cargo tanks, maximum filling level or percentage in liquid cargo tanks, 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 guidance deemed appropriate for the operation of the ship
- a table of contents and index for each booklet.

1.2 Loading conditions

1.2.1 General

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

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

Further loading cases may be included when deemed necessary or useful.

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

1.2.2 Ships carrying cargo on deck

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

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

1.2.3 General cargo ships

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

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

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

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

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

1.2.4 Container ships

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

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

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

1.2.5 Bulk carriers, ore carriers and combination carriers

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

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

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

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

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

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

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

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

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

1.2.6 Oil tankers and FLS tankers

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

Further cases are subject to prior examination by the Society before the loading; alternatively, an approved loading instrument capable of performing damage stability calculations in accordance with the requirements in Pt D, Ch 7, Sec 3, [1] may be used.

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

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

  When it is impossible to have segregations, these conditions are to be replaced by loading conditions with the same specific gravity and with slack cargo tanks

- same loading condition as above, but with 10% stores and consumables
- for oil tankers having segregated ballast tanks as defined in Pt D, Ch 7, Sec 2, [2], the lightship condition with segregated ballast only is also to be included in the trim and stability booklet for examination.

1.2.7 Chemical tankers

All the intended cargo loading conditions are to be included in the trim and stability booklet for examination within the scope of Pt D, Ch 8, Sec 2, [6].

Further cases are subject to prior examination by the Society before the loading; alternatively, an approved loading instrument capable of performing damage stability calculations in accordance with Pt D, Ch 8, Sec 2, [6] may be used.

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

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

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

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

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

1.2.8 Liquefied gas carriers

All the intended cargo loading conditions are to be included in the trim and stability booklet for examination within the scope of Pt D, Ch 9, Sec 2, [6].

Further cases are subject to prior examination by the Society before the loading; alternatively, an approved loading instrument capable of performing damage stability calculations in accordance with Pt D, Ch 9, Sec 2, [6] may be used.

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

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

1.2.9 Passenger ships

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

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

1.2.10 Dredgers

For ships with one of the service notations **dredger**, **hopper dredger**, **hopper unit**, **split hopper dredger** and **split hopper unit**, the loading conditions described in a) and b) are to replace the standard loading conditions defined in [1.2.1].

a) State of cargo: liquid

- ship loaded to the dredging draught with cargo considered as a liquid
- hopper(s) fully loaded with a homogeneous cargo having density ρ_m, up to the spill out edge of the hopper coaming:

  $\rho_m = M_1 / V_1$

  M_1 : Mass of cargo, in t, in the hopper when loaded at the dredging draught

  V_1 : Volume, in m^3, of the hopper at the spill out edge of the hopper coaming.

  The conditions of stores and fuel are to be equal to 100% and 10%, and an intermediate condition is to be considered if it is more critical than both 100% and 10%.

- hopper(s) filled or partly filled with a homogeneous cargo having densities equal to 1000, 1200, 1400, 1600, 1800 and 2000 kg/m^3

  When the dredging draught cannot be reached due to the density of the cargo, the hopper is to be considered filled up to the spill out edge of the hopper coaming.

  The conditions of stores and fuel are to be the most conservative obtained from the stability calculations with the density ρ_m.

b) State of the cargo: solid

- ship loaded to the dredging draught with cargo considered as a solid
- hopper(s) fully loaded with a homogeneous cargo having density ρ_m up to the spill out edge of the hopper coaming, as calculated in a)

  The conditions of stores and fuel are to be equal to 100% and 10%, and an intermediate condition is to be considered if it is more conservative than both 100% and 10%.

- hopper(s) filled or partly filled with a homogeneous cargo having densities equal to 1400, 1600, 1800, 2000 and 2200 kg/m^3 if greater than ρ_m.

1.2.11 Tugs and fire-fighting ships

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

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

1.2.12 Supply vessels

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

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

1.2.13 Fishing vessels

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

- departure conditions for the fishing grounds with full fuel stores, ice, fishing gear, etc.
- departure from the fishing grounds with full catch
- arrival at home port with 10% stores, fuel, etc. remaining and full catch
- arrival at home port with 10% stores, fuel, etc. and a minimum catch, which is normally to be 20% of the full catch but may be up to 40% if documented.

1.2.14 Ships having the additional service feature SPxxx

In addition to the standard loading conditions specified in [1.2.1], for ships with the additional service feature **SPxxx** the following loading cases are to be included in the trim and stability booklet:

- ship in the fully loaded departure condition, having cargo specified by position and weight, with full stores and fuel, and with the total number of persons on board, including crew, special personnel and passengers
- ship in the fully loaded arrival condition, with cargo and total number of persons as specified above, but with 10 per cent stores and fuel
- ship in the worst anticipated operating condition.

1.3 Stability curve calculation

1.3.1 General

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

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

1.3.2 Superstructures, deckhouses, etc. which may be taken into account

Enclosed superstructures complying with Ch 1, Sec 2, [3.13] may be taken into account.

The second tier of similarly enclosed superstructures may also be taken into account.

Deckhouses on the freeboard deck may be taken into account, provided that they comply with the conditions for enclosed superstructures laid down in Ch 1, Sec 2, [3.16].

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, [9] or Ch 8, Sec 8, as relevant.

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

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

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

1.3.3 Angle of flooding

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

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

APPENDIX 3 PROBABILISTIC DAMAGE STABILITY METHOD FOR CARGO SHIPS

1 Probabilistic damage stability method for cargo ships

1.1 Application

1.1.1 *The requirements included in this Appendix are to be applied to cargo ships over 80 m in length L_S as defined in [1.2.4], but are not to be applied to those ships which are shown to comply with subdivision and damage stability regulations* already required in Part D.

Any reference hereinafter to regulations refers to the set of regulations contained in this Appendix.

The Society may, for a particular ship or group of ships, accept alternative arrangements, if it is satisfied that at least the same degree of safety as represented by these regulations is achieved.

This includes, for example, the following:

- ships constructed in accordance with a standard of damage stability with a set of damage criteria agreed by the Society
- ships of a multi-hull design, where the subdivision arrangements need to be evaluated against the basic principles of the probabilistic method since the regulations have been written specifically for mono-hulls.

1.1.2 The requirements of this Appendix are to be applied in conjunction with the explanatory notes as set out by the IMO resolution MSC 281 (85).

1.2 Definitions

1.2.1 Deepest subdivision draught

The deepest subdivision draught (d_S) is the waterline which corresponds to the summer load line draught of the ship.

1.2.2 Light service draught

Light service draught (d_L) is the service draught corresponding to the lightest anticipated loading and associated tankage, including, however, such ballast as may be necessary for stability and/or immersion.

1.2.3 Partial subdivision draught

The partial subdivision draught (d_P) is the light service draught plus 60% of the difference between the light service draught and the deepest subdivision draught.

1.2.4 Subdivision length L_s

The subdivision length L_s is the greatest projected moulded length of that part of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught.

1.2.5 Machinery space

Machinery spaces are spaces between the watertight boundaries of a space containing the main and auxiliary propulsion machinery, including boilers, generators and electric motors primarily intended for propulsion. In the case of unusual arrangements, the Society may define the limits of the machinery spaces.

1.2.6 Other definitions

Mid-length is the mid point of the subdivision length of the ship.

Aft terminal is the aft limit of the subdivision length.

Forward terminal is the forward limit of the subdivision length.

Breadth B is the greatest moulded breadth, in m, of the ship at or below the deepest subdivision draught.

Draught d is the vertical distance, in m, from the moulded baseline at mid-length to the waterline in question.

Permeability μ of a space is the proportion of the immersed volume of that space which can be occupied by water.

1.3 Required subdivision index R

1.3.1 *These regulations are intended to provide ships with a minimum standard of subdivision.*

The degree of subdivision to be provided is to be determined by the required subdivision index R, as follows:

- *for ships greater than 100 m in length L_S:*

$$R = 1 - \frac{128}{L_S + 152}$$

- *for ships of 80 m in length L_S and upwards, but not greater than 100 m in length L_S:*

$$R = 1 - \frac{1}{\left(1 + \frac{L_S}{100}\frac{R_0}{(1 - R_0)}\right)}$$

  where R_0 is the value of R as calculated in accordance with the formula given for ships greater than 100 m in length L_S.

1.4 Attained subdivision index A

1.4.1 *The attained subdivision index A is obtained by the summation of the partial indices A_S, A_P and A_L (weighed as shown), calculated for the draughts d_S, d_P and d_L defined in [1.2.1], [1.2.2] and [1.2.3], in accordance with the following formula:*

$A = 0{,}4\ A_S + 0{,}4\ A_P + 0{,}2\ A_L$

The attained subdivision index A is not to be less than the required subdivision index R. In addition, the partial indices A_S, A_P and A_L are not to be less than 0,5 R.

1.4.2 *Each partial index is a summation of contributions from all damage cases taken in consideration, using the following formula:*

$A = \Sigma\, p_i\, s_i$

where:

- i : *Represents each compartment or group of compartments under consideration*
- p_i : *Accounts for the probability that only the compartment or group of compartments under consideration may be flooded, disregarding any horizontal subdivision, as defined in [1.5]*
- s_i : *Accounts for the probability of survival after flooding the compartment or group of compartments under consideration, and includes the effects of any horizontal subdivision, as defined in [1.6].*

1.4.3 *In the calculation of A, the level trim is to be used for the deepest subdivision draught d_S and the partial subdivision draught d_P. The actual service trim is to be used for the light service draught d_L. If, in any service condition, the trim variation in comparison with the calculated trim is greater than 0,5% of L_s, one or more additional calculations of A are to be submitted for the same draughts but different trims so that, for all service conditions, the difference in trim in comparison with the reference trim used for one calculation is less than 0,5% of L_s.*

When determining the positive righting lever (GZ) of the residual stability curve, the displacement used is to be that of the intact condition. That is, the constant-displacement method of calculation is to be used.

The summation indicated by the formula in [1.4.2] is to be taken over the ship's subdivision length (L_s) for all cases of flooding in which a single compartment or two or more adjacent compartments are involved. In the case of unsymmetrical arrangements, the calculated A value is to be the mean value obtained from calculations involving both sides. Alternatively, it is to be taken as that corresponding to the side which evidently gives the least favourable result.

1.4.4 *Wherever wing compartments are fitted, contribution to the summation indicated by the formula is to be taken for all cases of flooding in which wing compartments are involved. Additionally, cases of simultaneous flooding of a wing compartment or group of compartments and the adjacent inboard compartment or group of compartments, but excluding damage of transverse extent greater than one half of the ship breadth B, may be added. For the purpose of this regulation, transverse extent is measured inboard from ship's side, at right angle to the centreline at the level of the deepest subdivision draught.*

1.4.5 *In the flooding calculations carried out according to the regulations, only one breach of the hull and only one free surface need to be assumed. The assumed vertical extent of damage is to extend from the baseline upwards to any watertight horizontal subdivision above the waterline or higher. However, if a lesser extent of damage gives a more severe result, such extent is to be assumed.*

1.4.6 *If pipes, ducts or tunnels are situated within the assumed extent of damage, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed flooded. However, the Society may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the ship is not impaired.*

1.5 Calculation of factor p_i

1.5.1 *The factor p_i for a compartment or group of compartments is to be calculated in accordance with [1.5.2] to [1.5.6] using the following notations:*

- j : *The aftmost damage zone number involved in the damage starting with no.1 at the stern*
- n : *The number of adjacent damage zones involved in the damage*
- k : *The number of a particular longitudinal bulkhead as barrier for transverse penetration in a damage zone, counted from shell towards the centreline. The shell has k = 0*
- x_1 : *The distance from the aft terminal of L_s to the aft end of the zone in question*
- x_2 : *The distance from the aft terminal of L_s to the forward end of the zone in question*
- b : *The mean transverse distance, in metres, measured at right angles to the centreline at the deepest subdivision draught between the shell and an assumed vertical plane extended between the longitudinal limits used in calculating the factor p_i and which is a tangent to, or common with, all or part of the outermost portion of the longitudinal bulkhead under consideration. This vertical plane is to be so orientated that the mean transverse distance to the shell is a maximum, but not more than twice the least distance between the plane and the shell. If the upper part of a longitudinal bulkhead is below the deepest subdivision draught the vertical plane used for determination of b is assumed to extend upwards to the deepest subdivision waterline. In any case, b is not to be taken greater than B/2.*

If the damage involves a single zone only:

$$p_i = p(x_{1(j)}, x_{2(j)}) \cdot [r(x_{1(j)}, x_{2(j)}, b_k) - r(x_{1(j)}, x_{2(j)}, b_{(k-1)})]$$

If the damage involves two adjacent zones:

$$\begin{aligned} p_i = {} & p(x_{1(j)}, x_{2(j+1)}) \cdot [r(x_{1(j)}, x_{2(j+1)}, b_k) - r(x_{1(j)}, x_{2(j+1)}, b_{(k-1)})] \\ & - p(x_{1(j)}, x_{2(j)}) \cdot [r(x_{1(j)}, x_{2(j)}, b_k) - r(x_{1(j)}, x_{2(j)}, b_{(k-1)})] \\ & - p(x_{1(j+1)}, x_{2(j+1)}) \cdot [r(x_{1(j+1)}, x_{2(j+1)}, b_k) - r(x_{1(j+1)}, x_{2(j+1)}, b_{(k-1)})] \end{aligned}$$

If the damage involves three or more adjacent zones:

$$\begin{aligned} p_i = {} & p(x_{1(j)}, x_{2(j+n-1)}) \cdot [r(x_{1(j)}, x_{2(j+n-1)}, b_k) - r(x_{1(j)}, x_{2(j+n-1)}, b_{(k-1)})] \\ & - p(x_{1(j)}, x_{2(j+n-2)}) \cdot [r(x_{1(j)}, x_{2(j+n-2)}, b_k) - r(x_{1(j)}, x_{2(j+n-2)}, b_{(k-1)})] \\ & - p(x_{1(j+1)}, x_{2(j+n-1)}) \cdot [r(x_{1(j+1)}, x_{2(j+n-1)}, b_k) - r(x_{1(j+1)}, x_{2(j+n-1)}, b_{(k-1)})] \\ & + p(x_{1(j+1)}, x_{2(j+n-2)}) \cdot [r(x_{1(j+1)}, x_{2(j+n-2)}, b_k) - r(x_{1(j+1)}, x_{2(j+n-2)}, b_{(k-1)})] \end{aligned}$$

and where $r(x_1, x_2, b_0) = 0$

1.5.2 *The factor $p(x_1, x_2)$ is to be calculated according to the formulae given in [1.5.3] to [1.5.5],*

with:

J_{max} : *Overall normalized max damage length*

$J_{max} = 10 / 33$

J_{kn} : *Knuckle point in the distribution*

$J_{kn} = 5 / 33$

p_k : *Cumulative probability at J_{kn}*

$p_k = 11 / 12$

ℓ_{max} : *Maximum absolute damage length*

$\ell_{max} = 60$ m

L^* : *Length where normalized distribution ends*

$L^* = 260$ m

b_0 : *Probability density at $J = 0$*

$$b_0 = 2\left(\frac{p_k}{J_{kn}} - \frac{1-p_k}{J_{max} - J_{kn}}\right)$$

- *when $L_s \le L^*$:*

$$J_m = \min\left\{J_{max}, \frac{\ell_{max}}{L_s}\right\}$$

$$J_k = \frac{J_m}{2} + \frac{1 - \sqrt{1 + (1-2p_k)b_0 \cdot J_m + \frac{1}{4}b_0^2 \cdot J_m^2}}{b_0}$$

$$b_{12} = b_0$$

- *when $L_s > L^*$:*

$$J_m^* = \min\left\{J_{max}, \frac{\ell_{max}}{L^*}\right\}$$

$$J_k^* = \frac{J_m^*}{2} + \frac{1 - \sqrt{1 + (1-2p_k)b_0 \cdot J_m^* + \frac{1}{4}b_0^2 \cdot J_m^{*2}}}{b_0}$$

$$J_m = \frac{J_m^* \cdot L^*}{L_s}$$

$$J_k = \frac{J_k^* \cdot L^*}{L_s}$$

$$b_{12} = 2\left(\frac{p_k}{J_k} - \frac{1-p_k}{J_m - J_k}\right)$$

$$b_{11} = 4\frac{1-p_k}{(J_m - J_k)J_k} - 2\frac{p_k}{J_k^2}$$

$$b_{21} = -2\frac{1-p_k}{(J_m - J_k)^2}$$

$$b_{22} = -b_{21} \cdot J_m$$

J : *Non-dimensional damage length:*

$$J = \frac{x_2 - x_1}{L_s}$$

J_n : *Normalized length of a compartment or group of compartments, to be taken as the lesser of J and J_m.*

1.5.3 *Where neither limit of the compartment or group of compartments under consideration coincides with the aft or forward terminals:*

- *$J \le J_k$:*

$$p(x_1, x_2) = p_1 = \frac{1}{6}J^2(b_{11} \cdot J + 3b_{12})$$

- *$J > J_k$:*

$$p(x_1, x_2) = p_2 = -\frac{b_{11} \cdot J_k^3}{3} + \frac{(b_{11} \cdot J - b_{12})J_k^2}{2} + b_{12} \cdot J \cdot J_k - \frac{b_{21}(J_n^3 - J_k^3)}{3} + \frac{(b_{21} \cdot J - b_{22})(J_n^2 - J_k^2)}{2} + b_{22} \cdot J(J_n - J_k)$$

1.5.4 *Where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:*

- *$J \le J_k$:*

$$p(x_1, x_2) = \frac{1}{2}(p_1 + J)$$

- *$J > J_k$:*

$$p(x_1, x_2) = \frac{1}{2}(p_2 + J)$$

1.5.5 *Where the compartment or group of compartments considered extends over the entire subdivision length (L_s):*

$$p(x_1, x_2) = 1$$

1.5.6 *The factor $r(x_1, x_2, b)$ is to be determined by the following formula:*

$$r(x_1, x_2, b) = 1 - (1 - C) \cdot \left[1 - \frac{G}{p(x_1, x_2)}\right]$$

where:

$$C = 12J_b(-45J_b + 4)$$

with $J_b = b / (15\,B)$

- *where the compartment or group of compartments considered extends over the entire subdivision length (L_s):*

$$G = G_1 = \frac{1}{2}b_{11} \cdot J_b^2 + b_{12} \cdot J_b$$

- *where neither limit of the compartment or group of compartments under consideration coincides with the aft or forward terminals:*

$$G = G_2 = -\frac{1}{3}b_{11} \cdot J_0^3 + \frac{1}{2}(b_{11} \cdot J - b_{12})J_0^2 + b_{12} \cdot J \cdot J_0$$

with $J_0 = \min(J, J_b)$

- *where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:*

$$G = \frac{1}{2}(G_2 + G_1 \cdot J)$$

1.6 Calculation of factor s_i

1.6.1 *The factor s_i is to be determined for each case of assumed flooding involving a compartment or group of compartments according to the requirement indicated in [1.6.2] to [1.6.9].*

1.6.2 *The factor s_i is to be obtained from the following formula:*

$$s_i = K\left[\frac{GZ_{max}}{0,12} \cdot \frac{Range}{16}\right]^{\frac{1}{4}}$$

where:

- GZ_{max} : *Maximum positive righting lever, in metres, up to the angle θ_v. GZ_{max} is not to be taken as more than 0,12 m*
- *Range* : *Range of positive righting levers, in degrees, measured from the angle θ_e. The positive range is to be taken up to the angle θ_v. Range is not to be taken as more than 16°*
- θ_v : *Angle where the righting lever becomes negative, or angle at which an opening incapable of being closed weathertight becomes submerged*
- θ_e : *Final equilibrium heel angle, in degrees*

- *if $\theta_e \le \theta_{min}$: K = 1*
- *if $\theta_e \ge \theta_{max}$: K = 0*
- *otherwise:*

$$K = \sqrt{\frac{\theta_{max} - \theta_e}{\theta_{max} - \theta_{min}}}$$

with $\theta_{min} = 25°$ and $\theta_{max} = 30°$

1.6.3 *In all cases, s_i is to be taken as zero in those cases where the final waterline, taking into account sinkage, heel and trim, immerses:*

- *the lower edge of openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of factor s_i. Such openings are to include air-pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers; but openings closed by means of watertight manhole covers and flush scuttles, small watertight hatch covers, remotely operated sliding watertight doors, sidescuttles of the non-opening type as well as watertight access doors and hatch covers required to be kept closed at sea need not be considered.*
- *immersion of any vertical escape hatch in the bulkhead deck intended for compliance with the applicable requirements of Pt C, Ch 4, Sec 8*
- *any controls intended for the operation of watertight doors, equalization devices, valves on piping or on ventilation ducts intended to maintain the integrity of watertight bulkheads from above the bulkhead deck become inaccessible or inoperable*
- *immersion of any part of piping or ventilation ducts carried through a watertight boundary that is located within any compartment included in damage cases contributing to the attained index A, if not fitted with watertight means of closure at each boundary.*

1.6.4 *Unsymmetrical flooding is to be kept to a minimum consistent with the efficient arrangements. Where it is necessary to correct large angles of heel, the means adopted are, where practicable, to be self-acting, but in any case where controls to equalization devices are provided they are to be operable from above the bulkhead deck. These fittings, together with their controls, are to be acceptable to the Society. Suitable information concerning the use of equalization devices are to be supplied to the master of the ship.*

1.6.5 *Tanks and compartments taking part in such equalization are to be fitted with air pipes or equivalent means of sufficient cross-section to ensure that the flow of water into the equalization compartments is not delayed.*

1.6.6 *Where horizontal watertight boundaries are fitted above the waterline under consideration, the s-value calculated for the lower compartment or group of compartments is to be obtained by multiplying the value as determined in [1.6.2] by the reduction factor ν_m according to [1.6.7], which represents the probability that the spaces above the horizontal subdivision will not be flooded.*

1.6.7 *The factor ν_m is to be obtained from the following formula:*

$$\nu_m = \nu(H_{j,n,m}, d) - \nu(H_{j,n,m-1}, d)$$

where:

- $H_{j,n,m}$: *Least height above the baseline, in metres, within the longitudinal range of $x_1(j)...x_2(j+n-1)$ of the m^{th} horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration*
- $H_{j,n,m-1}$: *Least height above the baseline, in metres, within the longitudinal range of $x_1(j)...x_2(j+n-1)$ of the $(m-1)^{th}$ horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration*
- *j* : *The aft terminal of the damaged compartments under consideration*
- *m* : *Each horizontal boundary counted upwards from the waterline under consideration*
- *d* : *Draught in question, as defined in [1.2]*
- x_1, x_2 : *Terminals of the compartment or group of compartments considered in [1.5.1].*

1.6.8 *The factors $v(H_{j,n,m}, d)$ and $v(H_{j,n,m-1}, d)$ are to be obtained from the following formulae:*

- *if $(H_m - d) \le 7{,}8$ m:*

$$v(H, d) = 0,8\frac{(H-d)}{7,8}$$

- *in all other cases:*

$$v(H, d) = 0,8 + 0,2\left[\frac{(H-d) - 7,8}{4,7}\right]$$

where:

- *$v(H_{j,n,m}, d)$ is to be taken as 1, if H_m coincides with the uppermost watertight boundary of the ship within the range $(x_{1(j)} \dots x_{2(j+n-1)})$*
- *$v(H_{j,n,0}, d)$ is to be taken as 0.*

In no case is v_m to be taken as less than zero or more than 1.

1.6.9 *In general, each contribution dA to the index A in the case of horizontal subdivisions is obtained from the following formula:*

$$dA = p_i \cdot [v_1 \cdot s_{min1} + (v_2 - v_1) \cdot s_{min2} + \dots + (1 - v_{m-1}) \cdot s_{min\,m}]$$

where:

v_m : The v-value calculated in accordance with [1.6.7] and [1.6.8]

s_{min} : The least s-factor for all combinations of damages obtained when the assumed damage extends from the assumed damage height H_m downwards.

1.7 Permeability

1.7.1 *For the purpose of the subdivision and damage stability calculations* reported in this Appendix, *the permeability of each space or part of a space is to be as per Tab 1.*

Table 1 : Permeability

Spaces	Permeability
Appropriated to stores	0,60
Occupied by accommodations	0,95
Occupied by machinery	0,85
Void spaces	0,95
Intended for liquids	0 or 0,95 **(1)**
(1) whichever results in the more severe requirements	

1.7.2 *For the purpose of the subdivision and damage stability calculations* reported in this Appendix, *the permeability of each cargo compartment is to be as per Tab 2.*
Other figures for permeability may be used if substantiated by calculations.

Table 2 : Permeability of cargo compartments

Spaces	Permeability at draught		
	d_S	d_P	d_L
Dry cargo spaces	0,70	0,80	0,95
Container spaces	0,70	0,80	0,95
Ro-ro spaces	0,90	0,90	0,95
Cargo liquids	0,70	0,80	0,95

1.8 Stability information

1.8.1 *The master is to be supplied with such information satisfactory to the Society as is necessary to enable him by rapid and simple processes to obtain accurate guidance as to the stability of the ship under varying conditions of service. A copy of the stability information is to be furnished to the Society.*

1.8.2 Information to be submitted

The information is to include:

- *curves or tables of minimum operational metacentric height (GM) versus draught which assures compliance with the relevant intact and damage stability requirements, alternatively corresponding curves or tables of the maximum allowable vertical centre of gravity (KG) versus draught, or with the equivalents of either of these curves*
- *instructions concerning the operation of cross-flooding arrangements, and*
- *all other data and aids which might be necessary to maintain the required intact stability and stability after damage.*

1.8.3 *The stability information is to show the influence of various trims in cases where the operational trim range exceeds ± 0,5% of L_s.*

1.8.4 *For ships which have to fulfil the stability requirements of this Annex, information referred to in [1.8.2] is determined from considerations related to the subdivision index, in the following manner: Minimum required GM (or maximum permissible vertical position of centre of gravity KG) for the three draughts d_S, d_P and d_L are equal to the GM (or KG values) of corresponding loading cases used for the calculation of survival factor s_i. For intermediate draughts, values to be used are to be obtained by linear interpolation applied to the GM value only between the deepest subdivision draught and the partial subdivision draught and between the partial load line and the light service draught respectively. Intact stability criteria are also to be taken into account by retaining for each draught the maximum among minimum required GM values or the minimum of maximum permissible KG values for both criteria. If the subdivision index is calculated for different trims, several required GM curves are to be established in the same way.*

1.8.5 *When curves or tables of minimum operational metacentric height (GM) versus draught are not appropriate, the master is to ensure 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.*

APPENDIX 4 DAMAGE STABILITY CALCULATION FOR SHIPS ASSIGNED WITH A REDUCED FREEBOARD

1 Application

1.1 General

1.1.1 The requirements of this Appendix apply to:

- Type A ships having a length greater than 150 m, and
- Type B-60 ships and Type B-100 ships having a length greater than 100 m.

Any reference hereafter to regulations refers to the set of regulations contained in this Appendix.

2 Initial loading condition

2.1 Initial condition of loading

2.1.1 *The initial condition of loading before flooding is to be determined* according to [2.1.2] and [2.1.3].

2.1.2 *The ship is loaded to its summer load waterline on an imaginary even keel.*

2.1.3 *When calculating the vertical centre of gravity, the following principles apply:*

a) *Homogeneous cargo is carried.*

b) *All cargo compartments, except those referred to under c), but including compartments intended to be partially filled, are to be considered fully loaded except that in the case of fluid cargoes each compartment is to be treated as 98 per cent full.*

c) *If the ship is intended to operate at its summer load waterline with empty compartments, such compartments are to be considered empty provided the height of the centre of gravity so calculated is not less than as calculated under b).*

d) *Fifty per cent of the individual total capacity of all tanks and spaces fitted to contain consumable liquids and stores is allowed for. It is to be assumed that for each type of liquid, at least one transverse pair or a single centre line tank has maximum free surface, and the tank or combination of tanks to be taken into account are to be those where the effect of free surfaces is the greatest; in each tank the centre of gravity of the contents is to be taken at the centre of volume of the tank. The remaining tanks are to be assumed either completely empty or completely filled, and the distribution of consumable liquids between these tanks is to be effected so as to obtain the greatest possible height above the keel for the centre of gravity.*

e) *At an angle of heel of not more than 5 degrees in each compartment containing liquids, as prescribed in b) except that in the case of compartments containing consumable fluids, as prescribed in d), the maximum free surface effect is to be taken into account.*

   Alternatively, the actual free surface effects may be used, provided the methods of calculation are acceptable to the Society.

f) *Weights are to be calculated on the basis of Tab 1.*

Table 1 : Specific gravities

Weight item	Specific gravity, in t/m^3
Salt water	1,025
Fresh water	1,000
Fuel oil	0,950
Diesel oil	0,900
Lubricating oil	0,900

3 Damage assumptions

3.1 Damage dimension

3.1.1 *The principles* indicated in [3.1.2] to [3.1.5] *regarding the character of the assumed damage apply.*

3.1.2 *The vertical extent of damage in all cases is assumed to be from the base line upwards without limit.*

3.1.3 *The transverse extent of damage is equal to B/5 or 11,5 metres, whichever is the lesser, measured inboard from the side of the ship perpendicularly to the centre line at the level of the summer load waterline.*

3.1.4 *If damage of a lesser extent than specified in* [3.1.2] and [3.1.3] *results in a more severe condition, such lesser extent is to be assumed.*

3.1.5 *Except where otherwise required in [3.4.3], the flooding is to be confined to a single compartment between adjacent transverse bulkheads provided the inner longitudinal boundary of the compartment is not in a position within the transverse extent of assumed damage. Transverse boundary bulkheads of wing tanks, which do not extend over the full breadth of the ship are to be assumed not to be damaged, provided they extend beyond the transverse extent of assumed damage prescribed in [3.1.3].*

3.2 Steps and recesses

3.2.1 *If in a transverse bulkhead there are steps or recesses of not more than 3,05 metres in length located within the transverse extent of assumed damage as defined in [3.1.3], such transverse bulkhead may be considered intact and the* *adjacent compartment may be floodable singly. If, however, within the transverse extent of assumed damage there is a step or recess of more than 3,05 metres in length in a transverse bulkhead, the two compartments adjacent to this bulkhead are to be considered as flooded. The step formed by the after peak bulkhead and the after peak tank top is not to be regarded as a step for the purpose of this regulation.*

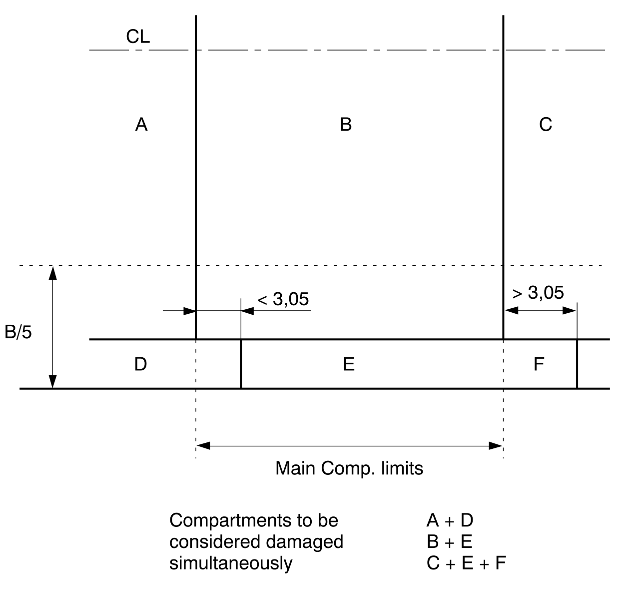
3.2.2 *Where a main transverse bulkhead is located within the transverse extent of assumed damage and is stepped in way of a double bottom or side tank by more than 3,05 metres, the double bottom or side tanks adjacent to the stepped portion of the main transverse bulkhead are to be considered as flooded simultaneously. If this side tank has openings into one or several holds, such as grain feeding holes, such hold or holds are to be considered as flooded simultaneously. Similarly, in a ship designed for the carriage of fluid cargoes, if a side tank has openings into adjacent compartments, such adjacent compartments are to be considered as empty and flooded simultaneously. This provision is applicable even where such openings are fitted with closing appliances, except in the case of sluice valves fitted in bulkheads between tanks and where the valves are controlled from the deck. Manhole covers with closely spaced bolts are considered equivalent to the unpierced bulkhead except in the case of openings in topside tanks making the topside tanks common to the holds.*

3.2.3 Where a transverse bulkhead forming the forward or aft limit of a wing tank or double bottom tank is not in line with the main transverse bulkhead of the adjacent inboard compartment, it is considered to form a step or recess in the main transverse bulkhead.

Such a step or recess may be assumed not to be damaged provided that, either:

- the longitudinal extent of the step or recess, measured from the plan of the main transverse bulkhead, is not more than 3,05 metres, or
- any longitudinal surface forming the step or recess is located inboard of the assumed damage.

Figure 1 : Step and recesses - Example 1



3.2.4 Where, otherwise, the transverse and longitudinal bulkheads bounding a main inboard compartment are entirely inboard of the assumed damage position, damage is assumed to occur between the transverse bulkheads and the adjacent wing compartment. Any step or recess in such wing tank is to be treated as indicated above.

Examples are shown in Fig 1 to Fig 4:

- Fig 1and Fig 2 refer to [3.2.2]
- Fig 3 and Fig 4 refer to [3.2.1] and [3.2.2].

3.3 Transverse bulkhead spacing

3.3.1 *Where the flooding of any two adjacent fore and aft compartments is envisaged, main transverse watertight bulkheads are to be spaced at least* $1/3(L)^{2/3}$ *or 14,5 metres, whichever is the lesser, in order to be considered effective. Where transverse bulkheads are spaced at a lesser distance, one or more of these bulkheads are to be assumed as nonexistent in order to achieve the minimum spacing between bulkheads.*

3.4 Damage assumption

3.4.1 *A Type A ship, if over 150 metres in length to which a freeboard less than Type B has been assigned, when loaded as considered in [2.1], is to be able to withstand the flooding of any compartment or compartments, with an assumed permeability of 0,95, consequent upon the damage assumptions specified in [3.1], and is to remain afloat in a satisfactory condition of equilibrium as specified in [3.5] and [3.6]. In such a ship, the machinery space is to be treated as a floodable compartment, but with a permeability of 0,85.* See Tab 2.

Figure 2 : Step and recesses - Example 2

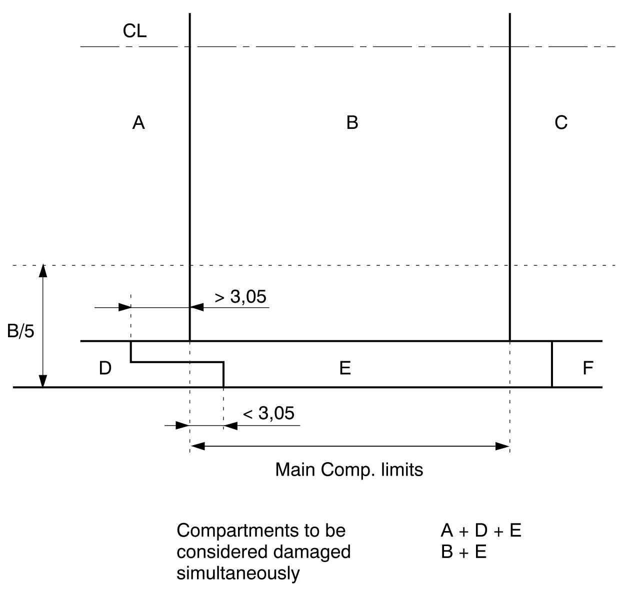


Figure 3 : Step and recesses - Example 3

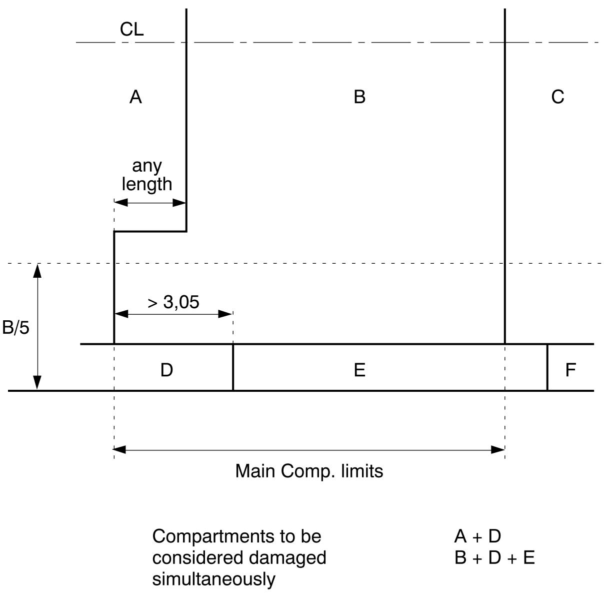


Figure 4 : Step and recesses - Example 4

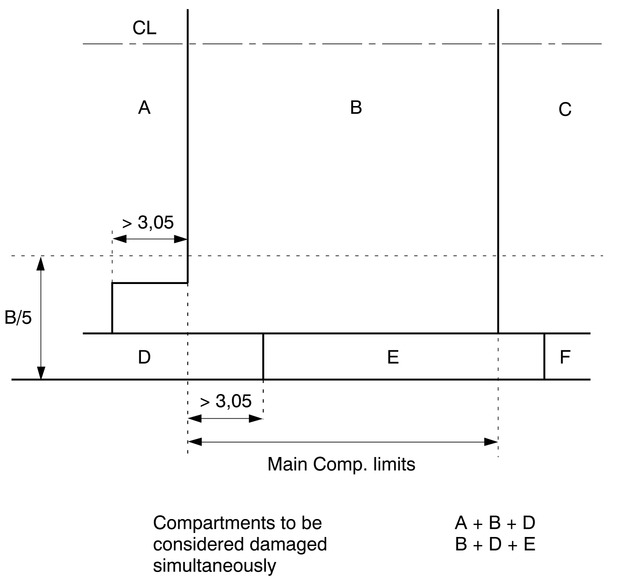


Table 2 : Damage assumption

Type	L, in m	Standard of flooding **(1)**
A	≥ 150	one compartment
B - 60	≥ 100	one compartment
B -100	≥ 100	two adjacent compartments (exemption for machinery space which is to be flooded alone)
(1) except where otherwise required by [4.2].		

3.4.2 *A Type B-60 ship, when loaded as considered in [2.1], is to be able to withstand the flooding of any compartment or compartments, with an assumed permeability of 0,95, consequent upon the damage assumptions specified in [3.1], and is to remain afloat in a satisfactory condition of equilibrium as specified in [3.5] and [3.6]. In such a ship, if over 150 metres in length, the machinery space is to be treated as a floodable compartment, but with a permeability of 0,85.* See Tab 2.

3.4.3 *A Type B-100 ship, when loaded as considered in [2.1], is to be able to withstand the flooding of any compartment or compartments, with an assumed permeability of 0,95, consequent upon the damage assumptions specified in [3.1], and is to remain afloat in a satisfactory condition of equilibrium as specified in [3.5] and [3.6]. Furthermore all the requirements stated in [4.1] are to be complied with, provided that throughout the length of the ship any one transverse bulkhead will be assumed to be damaged, such that two adjacent fore and aft compartments are to be flooded simultaneously, except that such damage will not apply to the boundary bulkheads of a machinery space. In such a ship, if over 150 metres in length, the machinery space is to be treated as a floodable compartment, but with a permeability of 0,85.* See Tab 2.

3.5 Condition of equilibrium

3.5.1 *The condition of equilibrium after flooding is to be regarded as satisfactory* according to [3.5.2] and [3.5.3].

3.5.2 *The final waterline after flooding, taking into account sinkage, heel and trim, is below the lower edge of any opening through which progressive downflooding may take place. Such openings are to include air pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers*, unless closed by watertight gasketed covers of steel or equivalent material, *and may exclude those openings closed by means of manhole covers and flush scuttles, cargo hatch covers, remotely operated sliding watertight doors, and side scuttles of the non-opening type. However, in the case of doors separating a main machinery space from a steering gear compartment, watertight doors may be of a hinged, quick acting type kept closed at sea, whilst not in use, provided also that the lower sill of such doors is above the summer load waterline.*

3.5.3 *If pipes, ducts or tunnels are situated within the assumed extent of damage penetration as defined in [3.1.3], arrangements are to be made so that progressive flooding cannot thereby extend to compartments other than those assumed to be floodable in the calculation for each case of damage.*

3.6 Damage stability criteria

3.6.1 *The angle of heel due to unsymmetrical flooding does not exceed 15 degrees. If no part of the deck is immersed, an angle of heel of up to 17 degrees may be accepted.*

3.6.2 *The metacentric height in the flooded condition is positive.*

3.6.3 *When any part of the deck outside the compartment assumed flooded in a particular case of damage is immersed, or in any case where the margin of stability in the flooded condition may be considered doubtful, the residual stability is to be investigated. It may be regarded as sufficient if the righting lever curve has a minimum range of 20 degrees beyond the position of equilibrium with a maximum righting lever of at least 0,1 metre within this range. The area under the righting lever curve within this range is to be not less than 0,0175 metre-radians. The Society is to give consideration to the potential hazard presented by protected or unprotected openings which may become temporarily immersed within the range of residual stability.*

3.6.4 *The Society is satisfied that the stability is sufficient during intermediate stages of flooding.* In this regard, the Society will apply the same criteria relevant to the final stage, also during the intermediate stages of flooding.

4 Requirements for Type B-60 and B-100 ships

4.1 Requirements for Type B-60 ships

4.1.1 *Any Type B ships of over 100 metres, having hatchways closed by weathertight covers as specified in [4.3], may be assigned freeboards less than those required for Type B, provided that, in relation to the amount of reduction granted, the* requirements in [4.1.2] to [4.1.4] are considered satisfactory by the Society.

In addition, the requirements stated in [3.4.2] are to be complied with.

4.1.2 *The measures provided for the protection of the crew are to be adequate.*

4.1.3 *The freeing arrangements are* to comply with the provisions of Ch 8, Sec 10.

4.1.4 *The covers in positions 1 and 2 comply with the provisions of [4.3] and have strength complying with Ch 8, Sec 7, special care being given to their sealing and securing arrangements.*

4.2 Requirements for Type B-100 ships

4.2.1 In addition to the requirements specified in [4.1], not taking into account the prescription stated in [3.4.2], the requirements in [4.2.2] to [4.2.4] are to be complied with.

In addition, the provisions of [3.4.3] are to be complied with.

4.2.2 Machinery casings

Machinery casings on Type A ships are to be protected by an enclosed poop or bridge of at least standard height, or by a deckhouse of equal height and equivalent strength, provided that machinery casings may be exposed if there are no openings giving direct access from the freeboard deck to the machinery space. A door complying with the requirements of [4.4] may, however, be permitted in the machinery casing, provided that it leads to a space or passageway which is as strongly constructed as the casing and is separated from the stairway to the engine room by a second weathertight door of steel or other equivalent material.

4.2.3 Gangway and access

An efficiently constructed fore and aft permanent gangway of sufficient strength is to be fitted on Type A ships at the level of the superstructure deck between the poop and the midship bridge or deckhouse where fitted, or equivalent means of access is to be provided to carry out the purpose of the gangway, such as passages below deck. Elsewhere, and on Type A ships without a midship bridge, arrangements to the satisfaction of the Society are to be provided to safeguard the crew in reaching all parts used in the necessary work of the ship.

Safe and satisfactory access from the gangway level is to be available between separate crew accommodation spaces and also between crew accommodation spaces and the machinery space.

4.2.4 Freeing arrangements

Type A ships with bulwarks are to be provided with open rails fitted for at least half the length of the exposed parts of the weather deck or other effective freeing arrangements. The upper edge of the sheer strake is to be kept as low as practicable.

Where superstructures are connected by trunks, open rails are to be fitted for the whole length of the exposed parts of the freeboard deck.

4.3 Hatchways closed by weathertight covers of steel or other equivalent material fitted with gaskets and clamping devices

4.3.1 At positions 1 and 2 the height above the deck of hatchway coamings fitted with weathertight hatch covers of steel or other equivalent material fitted with gaskets and clamping devices is to be:

- 600 millimetres if in position 1
- 450 millimetres if in position 2.

The height of these coamings may be reduced, or the coamings omitted entirely, upon proper justification. Where coamings are provided they are to be of substantial construction.

4.3.2 *Where weathertight covers are of mild steel the strength is to be calculated with assumed loads not less than those specified in Ch 8, Sec 7.*

4.3.3 *The strength and stiffness of covers made of materials other than mild steel are to be equivalent to those of mild steel to the satisfaction of the Society.*

4.3.4 *The means for securing and maintaining weathertightness are to be to the satisfaction of the Society. The arrangements are to ensure that the tightness can be maintained in any sea conditions, and for this purpose tests for tightness are required at the initial survey, and may be required at periodical surveys and at annual inspections or at more frequent intervals.*

4.4 Doors

4.4.1 *All access openings in bulkheads at ends of enclosed superstructures are to be fitted with doors of steel or other equivalent material, permanently and strongly attached to the bulkhead, and framed, stiffened and fitted so that the whole structure is of equivalent strength to the unpierced bulkhead and weathertight when closed. The means for securing these doors weathertight are to consist of gaskets and clamping devices or other equivalent means and are to be permanently attached to the bulkhead or to the doors themselves, and the doors are to be so arranged that they can be operated from both sides of the bulkhead.*

4.4.2 *Except as otherwise provided, the height of the sills of access openings in bulkheads at ends of enclosed superstructures is to be at least 380 millimetres above the deck.*

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 NR216 Materials and Welding.

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 NR216 Materials and Welding.

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 NR216 Materials and Welding. In particular:

- parent material and welding processes are to be 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.

In particular, for ships having the service notation **container ship**, higher strength steel with minimum specified yield stress R_{eH} equal to 460 N/mm² may be used in upper deck region (such as hatch side coaming, hatch coaming top and attached longitudinal stiffeners) provided that fatigue assessment is carried out for structural details (such as hatch corners) and for longitudinal structural members in this region.

Table 1 : Mechanical properties of hull steels

Steel grades $t \le 100$ mm	Minimum yield stress R_{eH}, in N/mm²	Ultimate minimum tensile strength R_m, in N/mm²
A-B-D-E	235	400 - 520
AH32-DH32 EH32-FH32	315	440 - 590
AH36-DH36 EH36-FH36 EH36CAS-FH36CAS	355	490 - 620
AH40-DH40 EH40- FH40 EH40CAS-FH40CAS	390	510 - 650
EH47CAS	460	570 - 720
Note 1: Ref.: NR216 Materials and Welding, Ch 2, Sec 1, [2]		

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

2.1.4 In case of steel used at a temperature θ between 90°C and 300°C, and when no other information is available, the minimum specified yield stress R_{eH} and the Young's modulus E of the steel at the temperature θ may be taken respectively equal to:

$$R_{eH} = R_{eH0}\left(1,04 - \frac{0,75}{1000}\theta\right)$$

$$E = E_0\left(1,03 - \frac{0,5}{1000}\theta\right)$$

where:

R_{eH0} : Value of the minimum specified yield stress at ambient temperature, in N/mm²

E_0 : Value of the Young's modulus at ambient temperature, in N/mm²

θ : Temperature of use of the steel, in °C.

2.1.5 Characteristics of steels with specified through thickness properties are given in NR216 Materials and Welding, Ch 2, Sec 1, [9].

2.2 Information to be kept on board

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

2.3 Material factor k

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

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

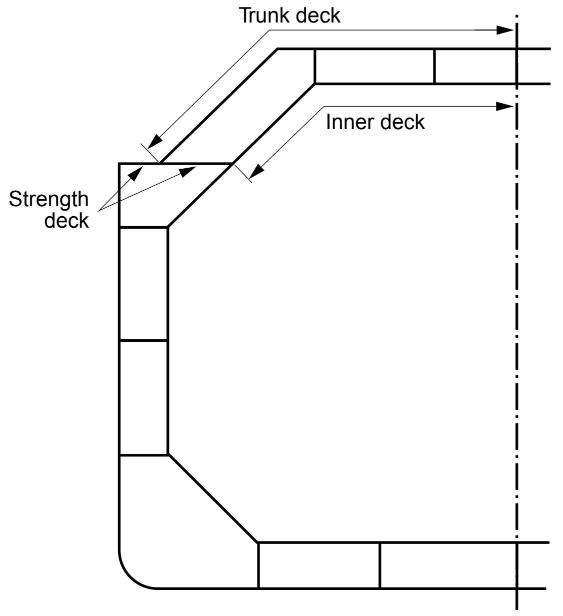
2.3.2 Steels with a yield stress lower than 235 N/mm^2 or greater than 390 N/mm^2 are considered by the Society on a case by case basis.

In particular, where higher strength steel having a minimum specified yield stress R_{eH} equal to 460 N/mm^2 are used according to [2.1.2], the material factor k is to be taken equal to 0,62.

Table 2 : Material factor k

R_{eH} , in N/mm^2	k
235	1,00
315	0,78
355	0,72
390	0,68

Figure 1 : Typical deck arrangement for membrane–type liquefied natural gas carriers



2.4 Grades of steel

2.4.1 Materials in the various strength members are not to be of lower grade than those corresponding to the material classes and grades specified in Tab 3, Tab 4, Tab 6, Tab 7 and Tab 8, and Tab 9.

General requirements are given in Tab 3. Additional minimum requirements are given in:

- Tab 4 for ships, excluding membrane-type liquefied gas carriers, greater than 150 m in length and having a single strength deck
- Tab 5 for membrane type liquefied gas carriers greater than 150 m in length and having a deck arrangement as shown in Fig 1

  Tab 5 may apply to similar ships with a double deck arrangement above the strength deck.
- Tab 6 for ships greater than 250 m in length
- Tab 7 for single-side **bulk carrier**, **bulk carrier ESP** and **combination carrier / OBO ESP**
- Tab 8 for ships with ice strengthening.

2.4.2 Materials are to be of a grade not lower than that indicated in Tab 9 depending on the material class and structural member gross thickness (see [2.4.5]).

2.4.3 For strength members not mentionned in Tab 3, Tab 4, Tab 5, Tab 6, Tab 7 and Tab 8, grade A/AH may generally be used.

2.4.4 Plating materials for sternframes supporting the rudder and propeller boss, rudders, rudder horns and shaft brachets 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.

2.4.5 The steel grade is to correspond to the as fitted gross thickness when this is greater than the gross thickness obtained from the net thickness required by the Rules, according to Ch 4, Sec 2, [1].

2.4.6 Steel grades of plates or sections of gross thickness greater than the limiting thicknesses in Tab 9 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.

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.

Table 3 : Application of material classes and grades for ships in general

Structural member category		Material class or grade	
		Within 0,4L amidships	Outside 0,4L amidships
SECONDARY	• Longitudinal bulkhead strakes, other than that belonging to the primary category • Deck plating exposed to weather, other than that belonging to the primary or special category • Side plating	I	A / AH
PRIMARY	• Bottom plating, including keel plate • Strength deck plating, excluding that belonging to the special category • Continuous longitudinal plating of strength members above strength deck, excluding hatch coamings, for ships equal to or greater than 90 m in length • Uppermost strake in longitudinal bulkhead • Vertical strake (hatch side girder) and uppermost sloped strake in top wing tank	II	A / AH
SPECIAL	• Sheer strake at strength deck **(1)** • Stringer plate in strength deck **(1)** • Deck strake at longitudinal bulkhead excluding deck plating in way of inner-skin bulkhead of double hull ships **(1)**	III	II I outside 0,6L amidships
	• Strength deck plating at outboard corners of cargo hatch openings in container carriers and other ships with similar hatch openings configurations	III	II I outside 0,6L amidships Min. class III within cargo region
	• Strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers, combination carriers and other ships with similar hatch openings configurations • Trunk deck and inner deck plating at corners of openings for liquid and gas domes in membrane type liquefied gas carriers	III	III within 0,6L amidships II within the rest of cargo region
	• Bilge strake in ships with double bottom over the full breadth and length less than 150 m	II	II within 0,6L amidships I outside 0,6L amidships
	• Bilge strake in other ships **(1)**	III	II I outside 0,6L amidships
	• Longitudinal hatch coamings of length greater than 0,15 L, including top plate and flange, for ships equal to or greater than 90 m in length • End brackets and deck house transition of longitudinal cargo hatch coamings	III Not to be less than grade D/DH	II I outside 0,6L amidships Not to be less than grade D/DH

(1) Single strakes required to be of class III within 0.4L amidships are to have breadths not less than (800 + 5 L) mm, need not to be greater than 1800 mm, unless limited by the geometry of the ship's design.

Table 4 : Application of material classes and grades for ships, excluding membrane-type liquefied gas carriers, greater than 150 m in length and having a single strength deck

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

Table 5 : Application of material classes and grades for membrane-type liquefied gas carriers, greater than 150 m in length

Structural member category		Material class or grade
Longitudinal plating of strength deck where contributing to the longitudinal strength		B/AH within 0,4 L amidships
Continuous longitudinal plating of strength members above the strength deck	Trunk deck plating	II within 0,4L amidships
	• Inner deck plating • Longitudinal strength member plating between the trunk deck and inner deck	B/AH within 0,4 L amidships

Table 6 : Application of material classes and grades for ships greater than 250 m in length

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

Table 7 : Application of material classes and grades for single-side bulk carrier, bulk carrier ESP and combination carrier / OBO ESP

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

Table 8 : Application of material classes and grades for ships with ice strengthening

Structural member category	Material grade
Shell strakes in way of ice strengthening area for plates	B/AH

Table 9 : Material grade requirements for classes I, II and III

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

2.4.10 In the case of full penetration welded joints located in positions where high local stresses may occur perpendicular to the continuous plating, the Society may, on a case by case basis, require the use of rolled products having adequate ductility properties in the through thickness direction, such as to minimize the risk of lamellar tearing (Z type steel, see NR216 Materials and Welding).

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

2.4.12 For ships having the service notation **container ship**, where higher strength steel having a minimum specified yield stress R_{eH} of 460 N/mm^2 is used for longitudinal structural members in the upper deck region (such as hatch side coaming, hatch coaming top and attached longitudinal stiffeners), the steel grade is to be EH47CAS.

2.5 Grades of steel for structures exposed to low air temperatures

2.5.1 For ships intended to operate in areas with low air temperatures (–20°C or below), 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 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 (at least 20 years)

Average : Average during one day and night

Lowest : Lowest during one year

Fig 2 illustrates the temperature definition for Arctic waters.

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

2.5.3 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 10.

Tab 10 also specifies the classes (I, II and III) of the materials to be used for the various categories of structural members.

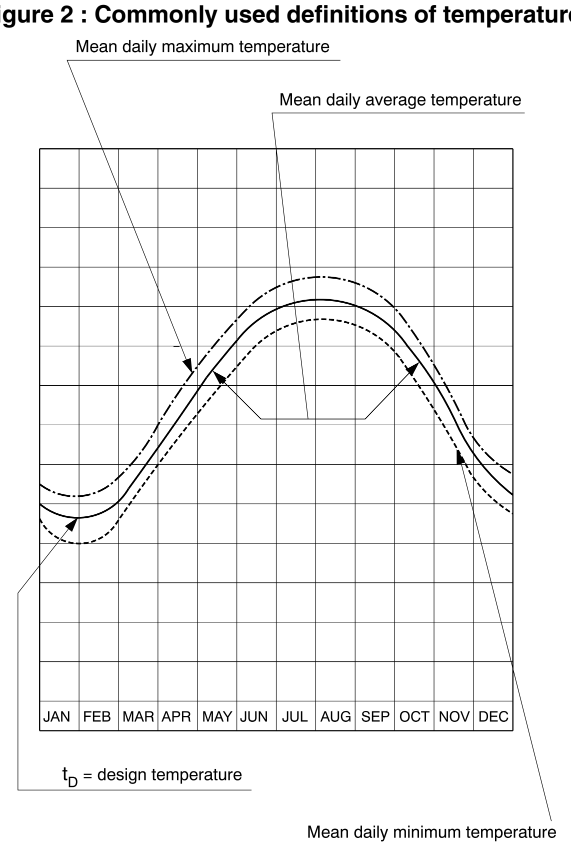
For non-exposed structures and structures below the lowest ballast waterline, see [2.4].

Table 10 : Application of material classes and grades - Structures exposed to low air temperatures

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)**	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)** Topside tank bulkhead above T_B **(1)**	II	I
SPECIAL: Sheer strake at strength deck **(3)** Stringer plate in strength deck **(3)** Deck strake at longitudinal bulkhead **(4)** Continuous longitudinal hatch coamings of ships equal to or greater than 90 m in length **(5)**	III	II

(1) T_B is the draught in light ballast condition, defined in Ch 5, Sec 1, [2.4.3].
(2) Plating at corners of large hatch openings to be considered on a case by case basis. Class III or grade E/EH to be applied in positions where high local stresses may occur.
(3) To be not less than grade E/EH within 0,4 L amidships in ships with length exceeding 250 m.
(4) In ships with breadth exceeding 70 metres at least three deck strakes to be class III.
(5) To be not less than grade D/DH.
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].

Figure 2 : Commonly used definitions of temperatures



2.5.4 Materials may not be of a lower grade than that indicated in Tab 11 to Tab 13 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 14, 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 14, steel having grades lower than those required in [2.4], Tab 3 and Tab 9, in relation to the class and gross thickness of the structural member considered, may not be used.

Table 11 : Material grade requirements for class I at low temperatures

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

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

Table 12 : Material grade requirements for class II at low temperatures

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

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

Table 13 : Material grade requirements for class III at low temperatures

Gross thickness, in mm	–20°C / –25°C		–26°C / –35°C		–36°C / –45°C		–46°C / –55°C	
	NSS	HSS	NSS	HSS	NSS	HSS	NSS	HSS
t ≤ 10	D	DH	D	DH	E	EH	E	EH
10 < t ≤ 20	D	DH	E	EH	E	EH	N.A.	FH
20 < t ≤ 25	E	EH	E	EH	E	FH	N.A.	FH
25 < t ≤ 30	E	EH	E	EH	N.A.	FH	N.A.	FH
30 < t ≤ 35	E	EH	N.A.	FH	N.A.	FH	N.A.	N.A.
35 < t ≤ 40	E	EH	N.A.	FH	N.A.	FH	N.A.	N.A.
40 < t ≤ 50	N.A.	FH	N.A.	FH	N.A.	N.A.	N.A.	N.A.

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

Table 14 : Material grade requirements for members within or adjacent to refrigerated spaces

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

2.7 Through thickness properties

2.7.1 Where normal tensile loads induce out-of-plane stress greater than 0,5 Ry in steel plates:

- for plates with t < 15 mm:

  ultrasonic testing is to be performed
- for plates with t ≥ 15 mm:

  Z-quality steel is to be used or ultrasonic testing is to be performed

in order to prevent laminar tearing.

The above mentioned ultrasonic testing is to be performed, before and after welding, on the area of the plate located within 50 mm or t, whichever is the greater, around the weld, in accordance with NR216 Materials and Welding, Ch 2, Sec 1, [9.10].

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 NR216 Materials and Welding.

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 NR216 Materials and Welding.

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 NR216 Materials and Welding, the above steels for forging are assigned to class 1 (see NR216 Materials and Welding, Ch 2, Sec 3, [1.2]).

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

In such case, compliance with the requirements of NR216 Materials and Welding, Ch 2, Sec 1, relevant to the quality and testing of rolled parts accepted in lieu of forged parts, may be required.

3.3 Steels for casting

3.3.1 Cast parts intended for stems, sternframes, rudders, parts of steering gear and deck machinery in general may be made of C and C-Mn weldable steels of quality 1, having specified minimum tensile strength R_m = 400 N/mm² or 440 N/mm², in accordance with the applicable requirements of NR216 Materials and Welding, Ch 2, Sec 4.

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

3.3.2 For the purpose of testing, which is to be carried out in accordance with NR216 Materials and Welding, Ch 2, Sec 4, 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 surface and volumetric 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 NR216 Materials and Welding, Ch 3, Sec 2.

Series 5000 aluminium-magnesium alloys or series 6000 aluminium-magnesium-silicon alloys are generally to be used (see NR216 Materials and Welding, Ch 3, Sec 2, [2]).

4.1.2 In the case of structures subjected to low service temperatures or intended for other specific applications, the alloys to be employed are to be agreed by the Society.

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

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 Mechanical properties of weld joints

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 The as welded properties of aluminium alloys of series 5000 are in general those of condition 0 or H111.

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

4.3.3 The as welded properties of aluminium alloys of series 6000 are to be agreed by the Society.

4.4 Material factor k

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

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

where:

R'_{lim} : Minimum specified yield stress of the parent metal in welded condition $R'_{p0,2}$, in N/mm², but not to be taken greater than 70% of the minimum specified tensile strength of the parent metal in welded condition R'_m , in N/mm²

$R'_{p0,2} = \eta_1 R_{p0,2}$

$R'_m = \eta_2 R_m$

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

Table 15 : Aluminium alloys for welded construction

Aluminium alloy	η_1	η_2
Alloys without work-hardening treatment (series 5000 in annealed condition 0 or annealed flattened condition H111)	1	1
Alloys hardened by work hardening (series 5000 other than condition 0 or H111)	$R'_{p0,2}/R_{p0,2}$	R'_m / R_m
Alloys hardened by heat treatment (series 6000) **(1)**	$R'_{p0,2}/R_{p0,2}$	0,6

(1) When no information is available, coefficient η_1 is to be taken equal to the metallurgical efficiency coefficient β defined in Tab 16.

Note 1:

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

R'_m : Minimum specified tensile stress, in N/mm², of material in welded condition (see [4.3]).

Table 16 : 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

R_m : Minimum specified tensile stress, in N/mm², of the parent metal in delivery condition.

η_1 and η_2 are given in Tab 15.

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.

4.4.3 For welded constructions in hardened aluminium alloys (series 5000 other than condition 0 or H111 and series 6000), greater characteristics than those in welded condition may be considered, provided that welded connections are located in areas where stress levels are acceptable for the alloy considered in annealed or welded condition.

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 to comply with the applicable requirements of NR216 Materials and Welding.

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 requirements for the acceptance of the materials concerned are to be agreed by the Society.

5.1.3 Materials used in welding processes are to comply with the applicable requirements of NR216 Materials and Welding.

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:

- obtained from the yielding checks of the hull girder in Ch 6, Sec 2
- of bow doors and inner doors in Ch 8, Sec 5
- of side doors and stern doors in Ch 8, Sec 6
- of rudder structures and hull appendages in Part B, Chapter 9
- 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 first 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 their corrosion additions, 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 Ch 4, 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:		
$w_G \le 200$ cm^3	0,070	0,4
$w_G > 200$ cm^3	0,035	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 strength characteristics to be used for the check of plating, ordinary stiffeners and primary supporting members

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

It is to be checked whether:

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

where:

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

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

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

2.1.7 Hull girder net strength characteristics to be used for the check of hull girder ultimate strength

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

It is to be checked whether:

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

where:

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

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

Where the above condition is not satisfied, the net scantling of plating and ordinary stiffeners constituting the transverse section are to be calculated on the basis of the corrosion additions ηt_c, where:

η : Coefficient to be calculated so that:

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

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 characteristics to be used for the check of plating, ordinary stiffeners and primary supporting members

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.

2.2.3 Hull girder net strength characteristics to be used for the check of hull girder ultimate strength

The hull girder strength characteristic calculation is to be carried out according to [2.1.7] by using the corrosion additions proposed by the Designer in lieu of t_c.

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 equal to:

- for plating with a gross thickness greater than 10 mm, the sum of the values specified in Tab 2 for one side exposure to each compartment
- for plating with a gross thickness less than or equal to 10 mm, the smallest of the following values:
  - 20 % of the gross thickness of the plating
  - 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.

Table 2 : Corrosion additions t_c , in mm, for each exposed side

Compartment type		General **(1)**	Special cases
Ballast tank **(2)**		1,00	1,25 in upper zone **(6)**
Cargo oil tank and fuel oil tank **(3)**	Plating of horizontal surfaces	0,75	1,00 in upper zone **(6)**
	Plating of non-horizontal surfaces	0,50	1,00 in upper zone **(6)**
	Ordinary stiffeners and primary supporting members	0,75	1,00 in upper zone **(6)**
Independant tank of ships with service notation **liquefied gas carrier (4)**		0,00	
Cofferdam in cargo area of ships with the service notation **liquefied gas carrier**		1,00	
Dry bulk cargo hold **(5)**	General	1,00	
	Inner bottom plating Side plating for single hull ship Inner side plating for double hull ship Sloping stool plate of hopper tanks and lower stool Transverse bulkhead plating	1,75	
	Frames, ordinary stiffeners and primary supporting members	1,00	1,50 in lower zone **(7)**
Tanks for fresh water		0.5	
Tanks for water-based mud		1.25	
Tanks for oil-based mud		1.25	
Tanks for drilling brines		1.25	
Moonpool		1.75	
Compartment located between independant tank and inner side of ships with the additional service feature **asphalt carrier**		1,00	
Hopper well of dredging ships		2,00	
Accommodation space		0,00	
Compartments other than those mentioned above Outside sea and air		0,50	

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

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

3.1.3 Corrosion additions for stainless steel

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

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

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

3.1.5 Corrosion additions for aluminium alloys

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

SECTION 3 STRENGTH PRINCIPLES

Symbols

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

- for steels in general:

  $E = 2,06 \cdot 10^5$ N/mm²

- for stainless steels:

  $E = 1,95 \cdot 10^5$ N/mm²

- for aluminium alloys:

  $E = 7,0 \cdot 10^4$ N/mm²

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

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

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

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

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

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

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

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

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

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

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

1 General principles

1.1 Structural continuity

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

1.1.2 The structural continuity is to be ensured:

- 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 and in way of areas with changes in framing system.

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

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

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

1.1.5 Openings are to be avoided, as far as practicable, in way of highly stressed areas.

Where necessary, the shape of openings is to be specially designed to reduce the stress concentration factors.

Openings are to be generally well rounded with smooth edges.

1.1.6 Primary supporting members are to be arranged in such a way that they ensure adequate continuity of strength. Abrupt changes in height or in cross-section are to be avoided.

1.2 Connections with higher strength steel

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

1.2.2 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 NR216 Materials, Ch 3, Sec 2, [4]).

2 Plating

2.1 Insert plates and doublers

2.1.1 A local increase in plating thickness is generally to be achieved through insert plates. Local doublers, which are normally only allowed for temporary repair, may however be accepted by the Society on a case by case basis.

In any case, doublers and insert plates are to be made of materials of a quality at least equal to that of the plates on which they are welded.

2.1.2 Doublers having width, in mm, greater than:

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

are to be fitted with slot welds, to be effected according to Ch 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:

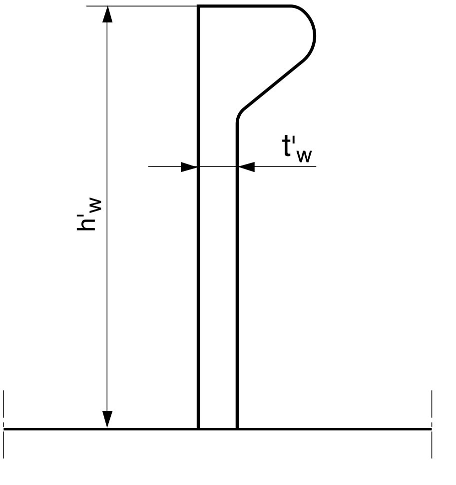
h'_w, t'_w : Height and net thickness of the bulb section, in mm, as shown in Fig 1

α : Coefficient equal to:

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

1 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.

3.2.2 Ordinary stiffeners connected by struts

The span of ordinary stiffeners connected by one or two struts, dividing the span in equal lengths, may be taken equal to $0,7\ell$.

Figure 2 : Ordinary stiffener without brackets

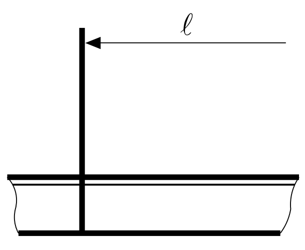


Figure 3 : Ordinary stiffener with a stiffener at one end

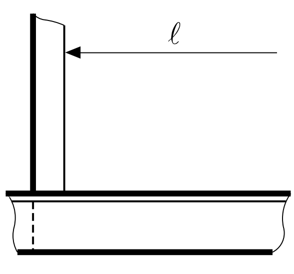


Figure 4 : Ordinary stiffener with end bracket

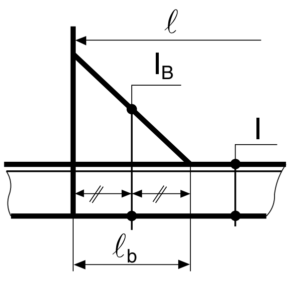
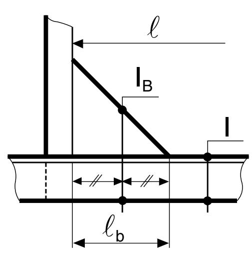


Figure 5 : Ordinary stiffener with a bracket and a stiffener at one end



3.3 Width of attached plating

3.3.1 Yielding check

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

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

  $b_P = s$

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

  $b_P = 0,5s$.

3.3.2 Buckling check and ultimate strength check

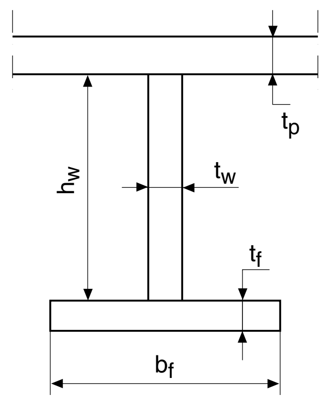
The attached plating to be considered for the buckling and ultimate strength check of ordinary stiffeners is defined in Ch 7, Sec 2, [4.1] and Ch 7, Sec 2, [5.2], respectively.

3.4 Geometric properties

3.4.1 Built section

The geometric properties of built sections as shown in Fig 6 may be calculated as indicated in the following formulae.

Figure 6 : Dimensions of a built section



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

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

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

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

The net moment of inertia of a built section with attached plating is to be obtained, in cm[4], from the following formula:

$I = w \cdot v$

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

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

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:

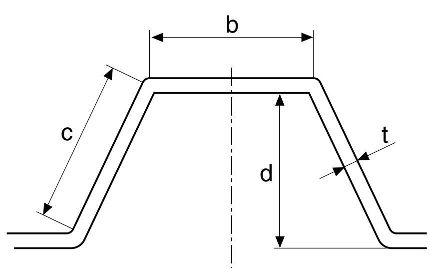
t : Net thickness of the plating of the corrugation, in mm

d, b, c : Dimensions of the corrugation, in mm, shown in Fig 7.

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

$w = 0{,}5\ b\ t\ d\ 10^{-3}$

Figure 7 : Dimensions of a corrugation



3.4.3 Plastic section modulus

The net plastic section modulus, Z_{pl}, of a built section with attached plating is to be obtained, in cm[3], from the following formula:

$$Z_{pl} = \frac{f_w h_w^2 t_w}{2000}\sin\alpha + (2\gamma - 1)\frac{t_f b_f\left(\left(h_w + \frac{t_f}{2}\right)\sin\alpha + b_{f-ctr}\cos\alpha\right)}{1000}$$

where:

f_w :
- $f_w = 1$ for flat bars or flanged profiles with no support at ends
- $f_w = 0{,}75$ for flanged profiles with at least one supported end

f_b :
- $f_b = 0{,}8$ for flanges contionuous through the primary structure, with end bracket(s)
- $f_b = 0{,}7$ for flanges sniped at the primary structure or terminated at the support without aligned structure on the other side of the support, and with end brackets
- $f_b = 1{,}0$ for other stiffeners

$$\gamma = 0{,}25(1 + \sqrt{3 + 12\beta})$$

b_{f-ctr} :
- $b_{f-ctr} = 0{,}5\ (b_f - t_w)$ for rolled angle profiles
- $b_{f-ctr} = 0$ for T profiles

β :
- $\beta = 0{,}5$ in general
- $\beta = \frac{t_w^2 f_b \ell^2}{80 b_f^2 t_f h_w}10^6 + \frac{t_w}{2 b_f}$

  for L profiles without mid-span tripping bracket.

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 8 to Fig 11.

Connection details other than those shown in Fig 8 to Fig 11 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 8 : End connection of ordinary stiffener Without collar plate

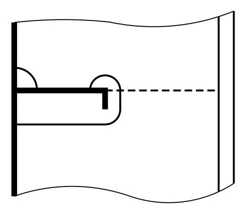


Figure 9 : End connection of ordinary stiffener Collar plate

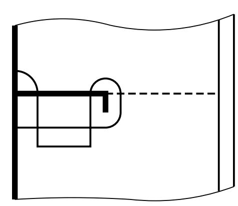


Figure 10 : End connection of ordinary stiffener One large collar plate

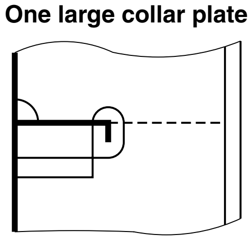
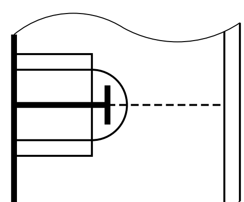


Figure 11 : End connection of ordinary stiffener Two large collar plates

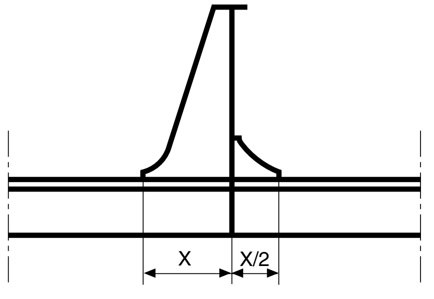


3.5.2 Where ordinary stiffeners are cut at primary supporting members, brackets are to be fitted to ensure the structural continuity. Their net section modulus and their net sectional area are to be not less than those of the ordinary stiffeners.

The net thickness of brackets is to be not less than that of ordinary stiffeners. Brackets with net thickness, in mm, less than $15L_b$, where L_b is the length, in m, of the free edge of the end bracket, are to be flanged or stiffened by a welded face plate. The net sectional area, in cm², of the flanged edge or face plate is to be at least equal to $10 L_b$.

3.5.3 Where necessary, the Society may require backing brackets to be fitted, as shown in Fig 12, in order to improve the fatigue strength of the connection (see also [4.7.4]).

Figure 12 : End connection of ordinary stiffener Backing bracket



4 Primary supporting members

4.1 Span of primary supporting members

4.1.1 The span of primary supporting members is to be determined in accordance with [3.2].

4.2 Width of attached plating

4.2.1 General

The width of the attached plating to be considered for the yielding check of primary supporting members analysed through beam structural models is to be obtained, in m, from the following formulae:

- where the plating extends on both sides of the primary supporting member:

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

- where the plating extends on one side of the primary supporting member (i.e. primary supporting members bounding openings):

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

4.2.2 Corrugated bulkheads

The width of attached plating of corrugated bulkhead primary supporting members is to be determined as follows:

- when primary supporting members are parallel to the corrugations and are welded to the corrugation flanges, the width of the attached plating is to be calculated in accordance with [4.2.1] and is to be taken not greater than the corrugation flange width
- when primary supporting members are perpendicular to the corrugations, the width of the attached plating is to be taken equal to the width of the primary supporting member face plate.

4.3 Geometric properties

4.3.1 Standard roll sections

The geometric properties of primary supporting members made of standard roll sections may be determined in accordance with [3.4.1], 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 13), their influence is to be taken into account by assigning an equivalent net shear sectional area to the primary supporting member.

This equivalent net shear sectional area is to be obtained, in cm², from the following formula:

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

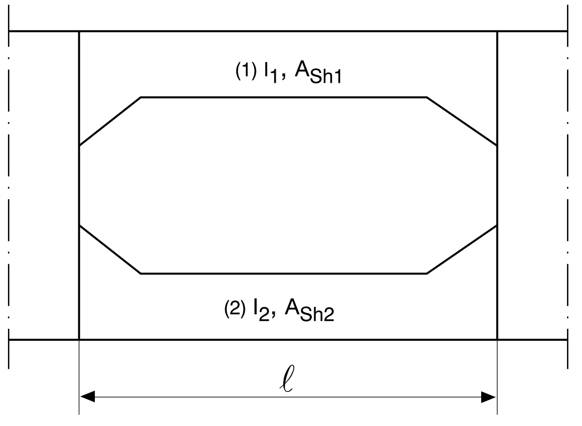
where (see Fig 13):

I_1, I_2 : Net moments of inertia, in cm⁴, of deep webs (1) and (2), respectively, with attached plating around their neutral axes parallel to the plating

A_{Sh1}, A_{Sh2} : Net shear sectional areas, in cm², of deep webs (1) and (2), respectively, to be calculated according to [4.3.2]

ℓ : Span, in cm, of deep webs (1) and (2).

Figure 13 : 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 Ch 4, 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.

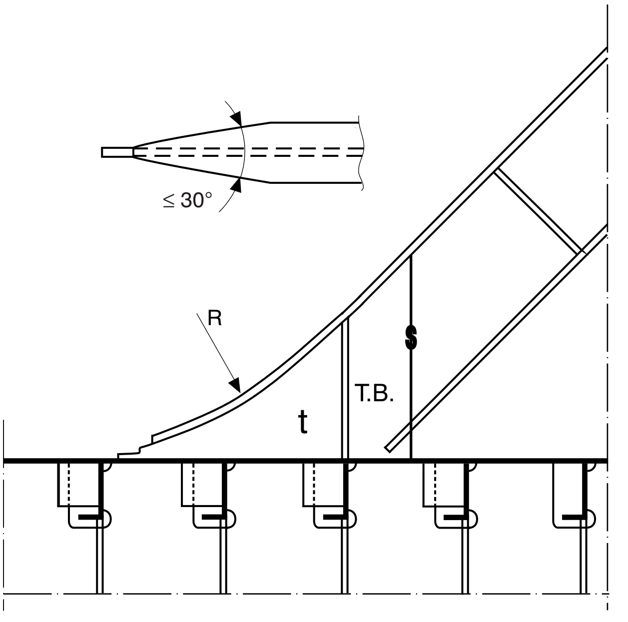
Moreover, the net thickness of the face plate is to be not less than that of the bracket web.

4.4.5 Where deemed necessary, face plates of end connecting brackets are to be symmetrical. In such a case, the following requirements are in general to be complied with:

- face plates are to be tapered at ends with a total angle not greater than 30°
- the breath of face plates at ends is not to be greater than 25 mm
- face plates of 20 mm thick and above are to be tapered in thickness at their ends down to their mid-thickness
- bracket toes are to be of increased thickness
- an additional tripping bracket is to be fitted
- the radius R of the face plate is to be as large as possible
- collar plates welded to the plating are to be fitted in way of the bracket toes
- throat thickness of fillet welds is not to be less than t/2, with t being the thickness of the bracket toe.

An example of bracket with symmetrical face plate is indicated in Fig 14.

Figure 14 : Bracket with symmetrical face plate



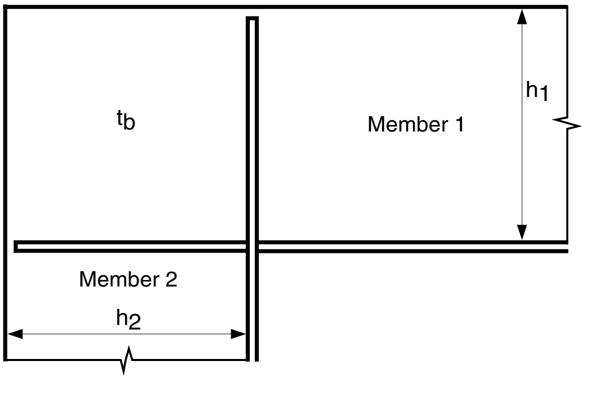
4.4.6 Stiffening of end brackets is to be designed such that it provides adequate buckling web stability.

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 cm², 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.

4.4.7 In addition to the above requirements, the net scantlings of end brackets are to comply with the applicable requirements given in Ch 4, Sec 4 to Ch 4, Sec 7.

Figure 15 : Bracketless end connections between two primary supporting members



4.5 Bracketless end connections

4.5.1 In the case of bracketless crossing between two primary supporting members (see Fig 15), the net thickness of the common part of the webs, in mm, is to be not less than the greatest value obtained from the following formula:

$$t_b = \frac{\gamma_R \gamma_m S f_1 \sigma_1}{0,5 h_2 R_y}$$

$$t_b = \frac{\gamma_R \gamma_m S f_2 \sigma_2}{0,5 h_1 R_y}$$

$t_b = \max(t_1, t_2)$

where:

- γ_R, γ_m : Partial safety factors as defined in Ch 7, Sec 3, [1.4]
- Sf_1, Sf_2 : Net flange section, in mm^2, of member 1 and member 2 respectively
- σ_1, σ_2 : Normal stresses, in N/mm^2, in member 1 and member 2 respectively
- t_1, t_2 : Net web thicknesses, in mm, of member 1 and member 2 respectively

4.5.2 In the case of bracketless crossing between three primary supporting members (see Fig 16), when the flange of member 2 and member 3 is continuous, the net thickness, in mm, of the common part of the webs is not to be less than the greater of:

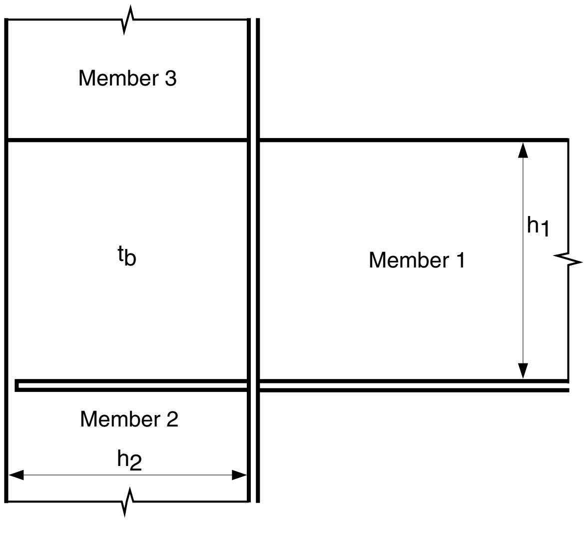
$$t_b = \frac{\gamma_R \gamma_m S f_1 \sigma_1}{0,5 h_2 R_y}$$

$t_b = \max(t_1, t_2)$

When the flanges of member 2 and member 3 are not continuous, the net thickness of the common part of the webs is to be defined as [4.5.1].

4.5.3 The common part of the webs is to be generally stiffened where the minimum height of the member 1 and member 2 is greater than $100 t_b$.

Figure 16 : Bracketless end connections between three primary supporting members



4.5.4 When lamellar tearing of flanges may occur, the flange in way of the connection may be requested to be of Z quality or a 100% ultrasonic testing of the flange in way of the weld may be required prior to and after welding.

4.6 Cut-outs and holes

4.6.1 Cut-outs for the passage of ordinary stiffeners are to be as small as possible and well rounded with smooth edges.

In general, the depth of cut-outs is to be not greater than 50% of the depth of the primary supporting member.

4.6.2 Where openings such as lightening holes are cut in primary supporting members, they are to be equidistant from the face plate and corners of cut-outs and, in general, their height is to be not greater than 20% of the web height.

4.6.3 Openings may not be fitted in way of toes of end brackets.

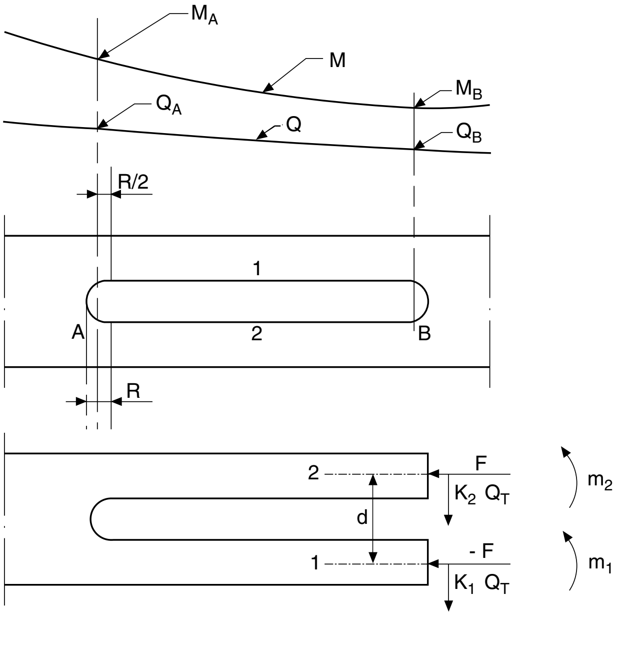
4.6.4 Over half of the span of primary supporting members, the length of openings is to be not greater than the distance between adjacent openings.

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 17, 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.

Figure 17 : Large openings in primary supporting members - Secondary stresses



Members (1) and (2) are subjected to the following forces, moments and stresses:

$$F = \frac{M_A + M_B}{2d}$$

$$m_1 = \left|\frac{M_A - M_B}{2}\right| K_1$$

$$m_2 = \left|\frac{M_A - M_B}{2}\right| K_2$$

$$\sigma_{F1} = 10\frac{F}{S_1}$$

$$\sigma_{F2} = 10\frac{F}{S_2}$$

$$\sigma_{m1} = \frac{m_1}{w_1}10^3$$

$$\sigma_{m2} = \frac{m_2}{w_2}10^3$$

$$\tau_1 = 10\frac{K_1 Q_T}{S_{w1}}$$

$$\tau_2 = 10\frac{K_2 Q_T}{S_{w2}}$$

where:

M_A, M_B : Bending moments, in kN.m, in sections A and B of the primary supporting member

m_1, m_2 : Bending moments, in kN.m, in (1) and (2)

d : Distance, in m, between the neutral axes of (1) and (2)

σ_{F1}, σ_{F2} : Axial stresses, in N/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, [4.4], 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 18 to Fig 20:

- continuous face plate (solution 1): see Fig 18
- straight face plate (solution 2): see Fig 19
- compensation of the opening (solution 3): see Fig 20
- combination of the above solutions.

Figure 18 : Stiffening of large openings in primary supporting members - Solution 1

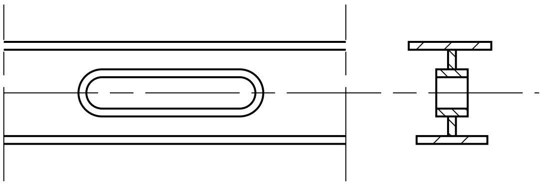


Figure 19 : Stiffening of large openings in primary supporting members - Solution 2

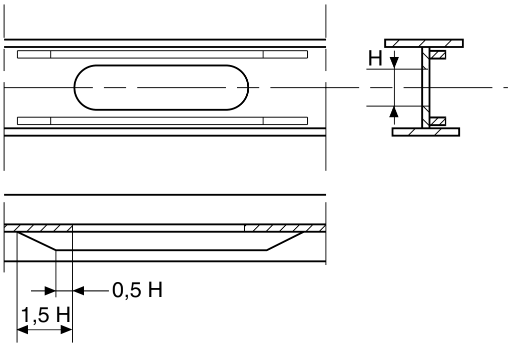
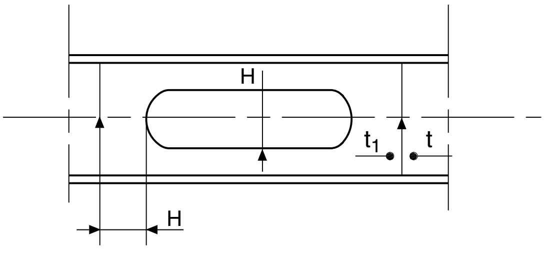


Figure 20 : Stiffening of large openings in primary supporting members - Solution 3

Inserted plate



Other arrangements may be accepted provided they are supported by direct calculations submitted to the Society for review.

4.7 Stiffening arrangement

4.7.1 Webs of primary supporting members are generally to be stiffened where the height, in mm, is greater than 100t, where t is the web net thickness, in mm, of the primary supporting member.

In general, the web stiffeners of primary supporting members are to be spaced not more than 110t.

4.7.2 Where primary supporting member web stiffeners are welded to ordinary stiffener face plates, their net sectional area at the web stiffener mid-height is to be not less than the value obtained, in cm^2, from the following formula:

$$A = 0{,}1 k_1 (\gamma_{S2} p_S + \gamma_{W2} p_W) s \ell$$

where:

k_1 : Coefficient depending on the web connection with the ordinary stiffener, to be taken as:

- $k_1 = 0{,}30$ for connections without collar plate (see Fig 8)

- k_1 = 0,225 for connections with a collar plate (see Fig 9)
- k_1 = 0,20 for connections with one or two large collar plates (see Fig 10 and Fig 11)

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)

ℓ : Span of ordinary stiffeners, in m

s : Spacing of ordinary stiffeners, in m.

4.7.3 The net moment of inertia, I, of the web stiffeners of primary supporting members is not to be less than the value obtained, in cm⁴, from the following formula:

- for web stiffeners parallel to the flange of the primary supporting members (see Fig 21):

$$I = C\ell^2 A\frac{R_{eH}}{235}$$

- for web stiffeners normal to the flange of the primary supporting members (see Fig 22):

$$I = 11{,}4\, s t_w (2{,}5\,\ell^2 - 2s^2)\frac{R_{eH}}{235}$$

where:

C : Slenderness coefficient to be taken as:
- C = 1,43 for longitudinal web stiffeners including sniped stiffeners
- C = 0,72 for other web stiffeners

ℓ : Length, in m, of the web stiffener

s : Spacing, in m, of web stiffeners

t_w : Web net thickness, in mm, of the primary supporting member

A : Net section area, in cm², of the web stiffener, including attached plate assuming effective breadth of 80% of stiffener spacing s

R_{eH} : Minimum specified yield stress of the material of the web plate of primary supporting member.

Figure 21 : Web stiffeners parallel to the flange

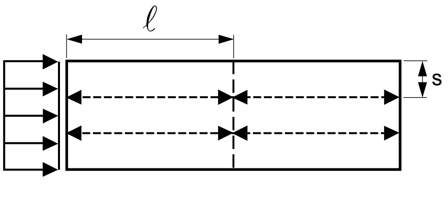
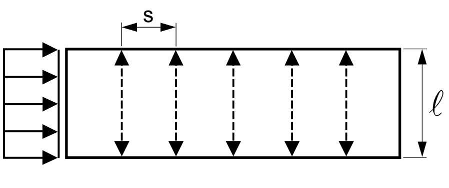


Figure 22 : Web stiffeners normal to the flange



4.7.4 Tripping brackets (see Fig 23) 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 23

s_t : Spacing, in m, of tripping brackets

t : Net thickness, in mm, of tripping brackets.

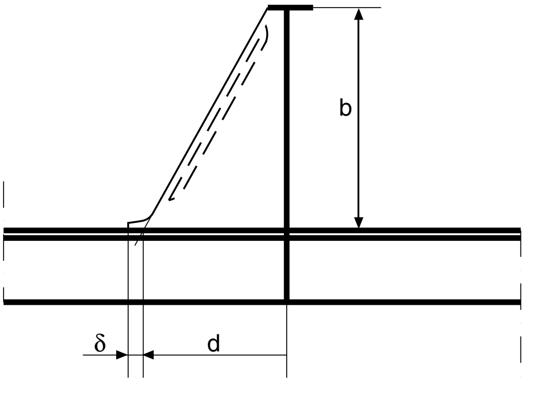
It is recommended that the bracket toe should be designed as shown in Fig 23.

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 23 : Tripping bracket



SECTION 4 BOTTOM STRUCTURE

1 General

1.1 Application

1.1.1 The requirements of this Section apply to longitudinally or transversely framed single and double bottom structures.

1.2 General arrangement

1.2.1 In ships greater than 120 m in length, the bottom is, in general, to be longitudinally framed.

1.2.2 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:

$$b = 0,8 + 0,5\frac{L}{100}$$

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 $\ell/16$. 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 given in Ch 2, Sec 2, [3].

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 for which damage stability requirements are to comply with, 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 $0,8\ L^{0,5}$.

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.

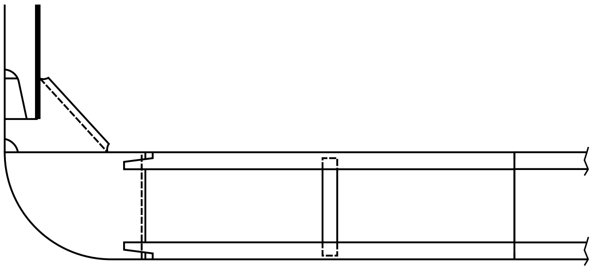
These stiffeners may consist of flat bars with a width equal to one tenth of the girder height and a net thickness, in mm, not less than $0,8L^{0,5}$.

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).

Figure 1 : Open floor



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.

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°.

In general, scallops and cut-outs are not to be used. Crack arresting holes are to be drilled in the bilge keel butt welds as close as practicable to the ground bar. The diameter of the hole is to be greater than the width W of the butt weld and is to be a minimum of 25 mm (see Fig 2). Where the butt weld has been subject to non-destructive examination, the crack arresting hole may be omitted.

The arrangement shown in Fig 2 is recommended.

The arrangement shown in Fig 3 may also be accepted.

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].

Figure 2 : Bilge keel arrangement

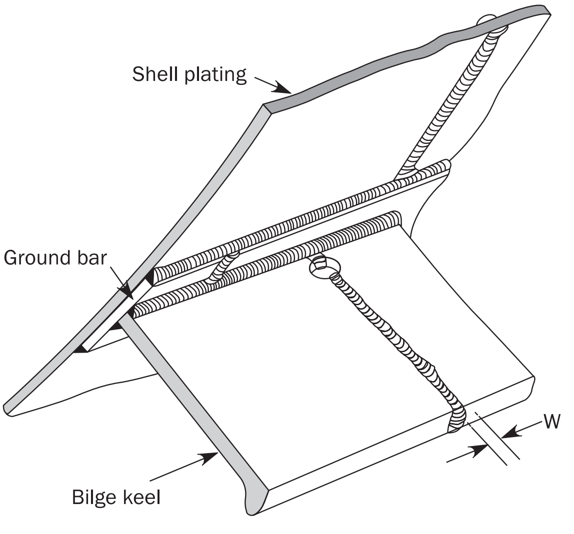
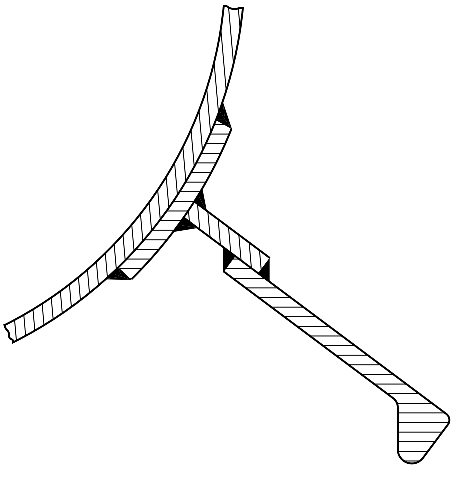


Figure 3 : Bilge keel alternative arrangement



SECTION 5 SIDE STRUCTURE

1 General

1.1 Application

1.1.1 The requirements of this Section apply to longitudinally or transversely framed single and double side structures.

1.1.2 The transversely framed side structures are built with transverse frames possibly supported by side girders (see [5.3.1]).

1.1.3 The longitudinally framed side structures are built with longitudinal ordinary stiffeners supported by side vertical primary supporting members.

1.2 General arrangement

1.2.1 Unless otherwise specified, side girders are to be fitted aft of the collision bulkhead up to 0,2L aft of the fore end, in line with fore peak girders.

1.2.2 Side vertical primary supporting members are to be fitted in way of hatch end beams.

1.3 Sheerstrake

1.3.1 The width of the sheerstrake is to be not less than the value obtained, in m, from the following formula (see also Ch 4, Sec 1, [2.4.5]):

$$b = 0{,}715 + 0{,}425\frac{L}{100}$$

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.

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 cm³, 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

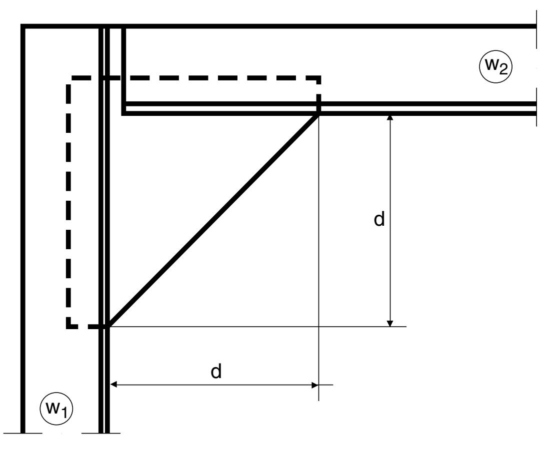
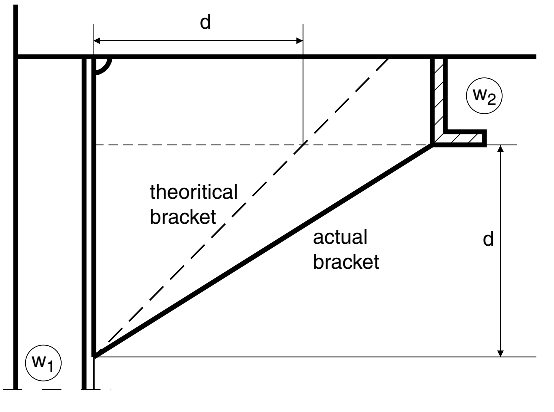


Figure 2 : Connections of stiffeners located in perpendicular planes



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

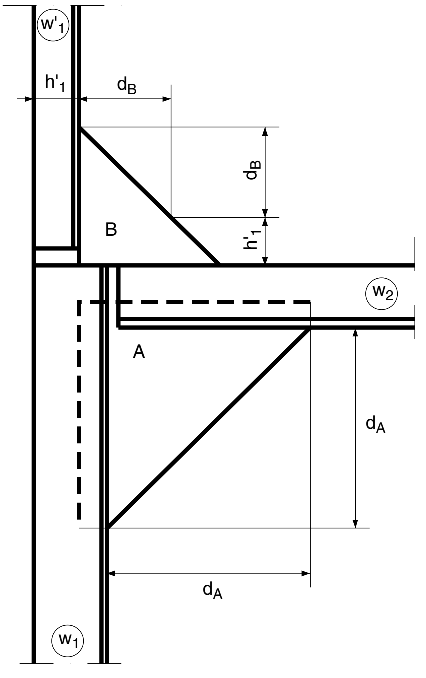
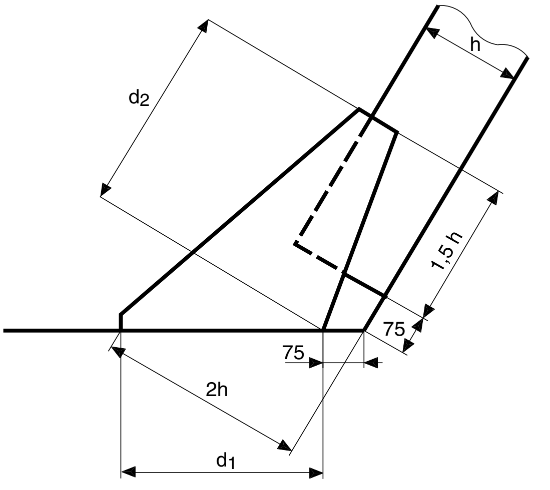


Figure 4 : Lower brackets of main frames



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: φ = 50
- for flanged brackets: φ = 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 15 L_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 10 L_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 Ch 4, 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.

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 (see also Ch 4, Sec 1, [2.4.5]):

$$b = 0{,}35 + 0{,}5\frac{L}{100}$$

However, the stringer plate is also to comply with the requirements in Ch 4, Sec 1, [2.4.5] and Ch 4, 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.

2.1.3 In case of deck transverses located above the deck, longitudinal girders are to be fitted above the deck, in addition of tripping brackets.

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 Ch 4, 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 or 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

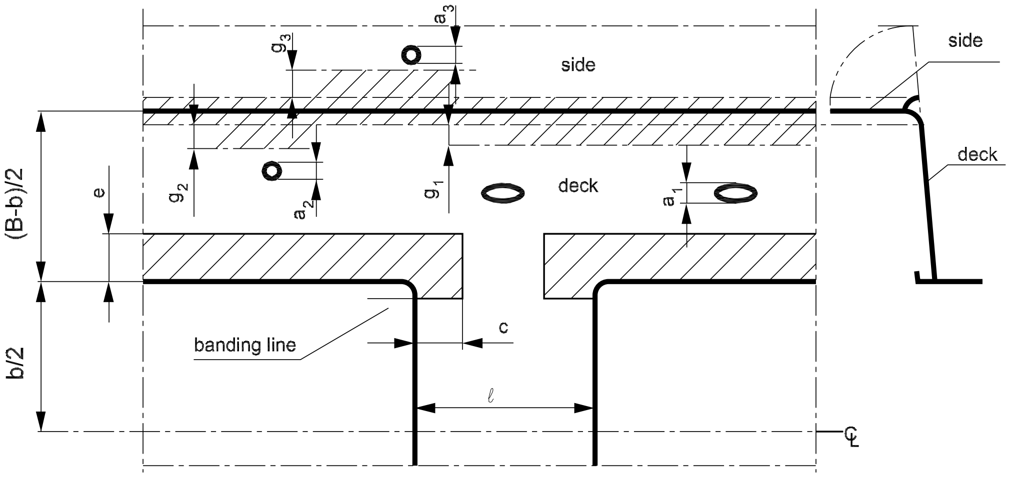
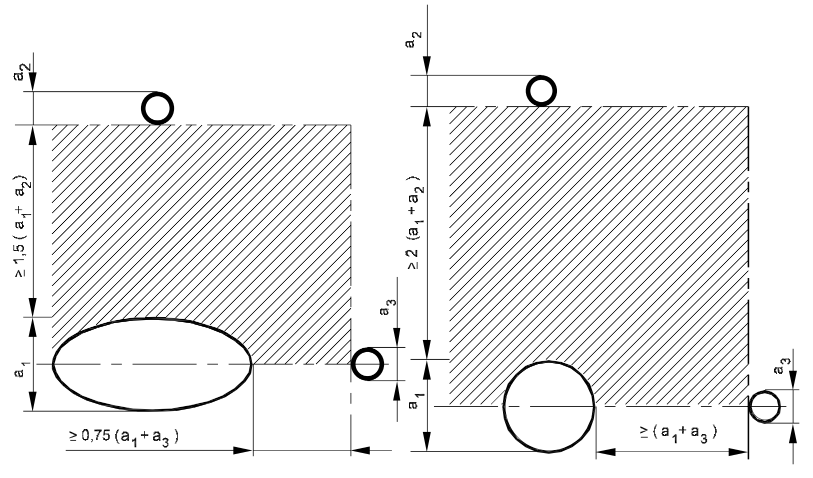


Figure 2 : Circular openings in the strength deck



6.1.3 If the openings arrangements do not comply with the requirements of the present Sub-Article, the hull girder longitudinal strength assessment is to be carried out by subtracting such opening areas.

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 permissible values.

6.2.4 Where insert plates are required, the arrangement shown in Ch 11, App 2, Tab 68 is to be complied with.

6.2.5 For hatchways located in positions other than those in [6.2.1], a reduction in the thickness of the insert plates in way of corners may be considered by the Society on a case by case basis.

7 Openings in decks other than the strength deck

7.1 General

7.1.1 The requirements for such openings are similar to those in [6.1] for the strength deck. However, circular openings need not to be compensated.

7.1.2 Corners of hatchway openings are to be rounded, as specified in [6.2] for the strength deck; insert plates may be omitted, however, when deemed acceptable by the Society.

SECTION 7 BULKHEAD STRUCTURE

1 General

1.1 Application

1.1.1 The requirements of this Section apply to longitudinal or transverse bulkhead structures which may be plane or corrugated.

1.1.2 Bulkheads may be horizontally or vertically stiffened.

Horizontally framed bulkheads consist of horizontal ordinary stiffeners supported by vertical primary supporting members.

Vertically framed bulkheads consist of vertical ordinary stiffeners which may be supported by horizontal girders.

1.2 General arrangement

1.2.1 The number and location of watertight bulkheads are to be in accordance with the relevant requirements given in Ch 2, Sec 1.

1.2.2 For ships greater than 170 m in length, longitudinal corrugated bulkheads are to have horizontal corrugations and the upper and lower strakes of longitudinal corrugated bulkheads are to be plane up to a distance of at least 0,1D from deck and bottom.

Transverse corrugated bulkheads having horizontal corrugations are to be fitted with vertical primary supporting members of number and size sufficient to ensure the required vertical stiffness of the bulkhead.

1.2.3 Where an inner bottom terminates on a bulkhead, the lowest strake of the bulkhead forming the watertight floor of the double bottom is to extend at least 300 mm above the inner bottom.

1.2.4 Longitudinal bulkheads are to terminate at transverse bulkheads and are to be effectively tapered to the adjoining structure at the ends and adequately extended in the machinery space, where applicable.

1.2.5 Where the longitudinal watertight bulkheads contribute to longitudinal strength, the plating thickness is to be uniform for a distance of at least 0,1D from the deck and bottom.

1.2.6 The structural continuity of the bulkhead vertical and horizontal primary supporting members with the surrounding supporting structures is to be carefully ensured.

1.2.7 The height of vertical primary supporting members of longitudinal bulkheads may be gradually tapered from bottom to deck. The maximum acceptable taper, however, is 8 cm per metre.

1.3 Watertight bulkheads of trunks, tunnels, etc.

1.3.1 *Watertight trunks, tunnels, duct keels and ventilators are to be of the same strength as watertight bulkheads at corresponding levels. The means used for making them watertight, and the arrangements adopted for closing openings in them, are to be to the satisfaction of the Society.*

1.4 Openings in watertight bulkheads

1.4.1 Openings may not be cut in the collision bulkhead below the freeboard deck.

The number of openings in the collision bulkhead above the freeboard deck is to be kept to the minimum compatible with the design and proper working of the ship.

All such openings are to be fitted with means of closing to weathertight standards.

1.4.2 Certain openings below the freeboard deck are permitted in the other bulkheads, but these are to be kept to a minimum compatible with the design and proper working of the ship and to be provided with watertight doors having strength such as to withstand the head of water to which they may be subjected.

1.5 Watertight doors

1.5.1 The net thickness of watertight doors is to be not less than that of the adjacent bulkhead plating, taking account of their actual spacing.

1.5.2 Where vertical stiffeners are cut in way of watertight doors, reinforced stiffeners are to be fitted on each side of the door and suitably overlapped; cross-bars are to be provided to support the interrupted stiffeners.

1.5.3 Watertight doors required to be open at sea are to be of the sliding type and capable of being operated both at the door itself, on both sides, and from an accessible position above the bulkhead deck.

Means are to be provided at the latter position to indicate whether the door is open or closed, as well as arrows indicating the direction in which the operating gear is to be operated.

1.5.4 Watertight doors may be of the hinged type if they are always intended to be closed during navigation.

Such doors are to be framed and capable of being secured watertight by handle-operated wedges which are suitably spaced and operable at both sides.

2 Plane bulkheads

2.1 General

2.1.1 Where a bulkhead does not extend up to the uppermost continuous deck (such as the after peak bulkhead), suitable strengthening is to be provided in the extension of the bulkhead.

2.1.2 Bulkheads are to be stiffened in way of deck girders.

2.1.3 The webs of vertical stiffeners on hopper and topside tank watertight transverse bulkheads are generally to be aligned with the webs of longitudinal stiffeners on sloping plates of inner hull.

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 The crossing of ordinary stiffeners through a watertight bulkhead is to be watertight.

2.2.2 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.

2.2.3 Where hull lines do not enable compliance with the requirements of [2.2.2], sniped ends may be accepted, provided the scantlings of stiffeners are modified accordingly.

2.2.4 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.

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.

Figure 1 : Bracket at upper end of ordinary stiffener on plane bulkhead

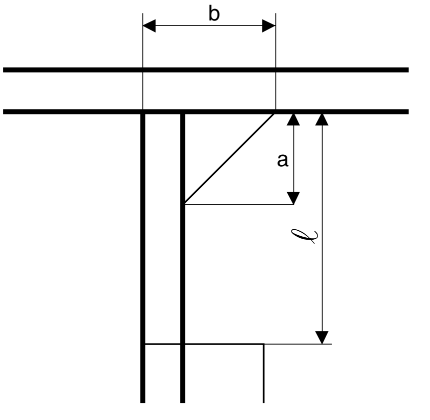
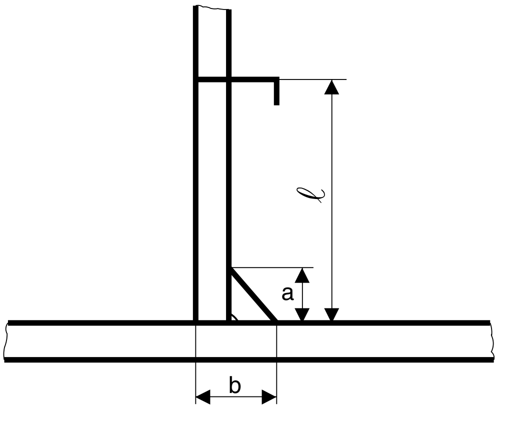


Figure 2 : Bracket at lower end of ordinary stiffener on plane bulkhead



3 Corrugated bulkheads

3.1 General

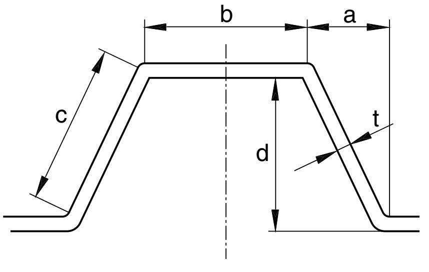
3.1.1 The main dimensions a, b, c and d of corrugated bulkheads are defined in Fig 3.

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

$a \leq 1,2 d$

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

Figure 3 : Corrugated bulkhead



3.1.3 In general, the bending internal radius is to be not less than the following values, in mm:

- for normal strength steel:

  $R_i = 2,5\ t$

- for high tensile steel:

  $R_i = 3,0\ t$

where t is the net thickness, in mm, of the corrugated plate.

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

Moreover, when the gross thickness of the bulkhead plating is greater than 20 mm, the Society may require the use of steel grade E or EH.

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

3.2 Structural arrangement

3.2.1 The strength continuity of corrugated bulkheads is to be ensured at ends of corrugations.

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

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

3.2.4 In general, where vertically corrugated transverse bulkheads are welded on the inner bottom, plate floors are to be fitted in way of the flanges of corrugations.

However, other arrangements ensuring adequate structural continuity may be accepted by the Society.

3.2.5 In general, where vertically corrugated longitudinal bulkheads are welded on the inner bottom, girders are to be fitted in way of the flanges of corrugations.

However, other arrangements ensuring adequate structural continuity may be accepted by the Society.

3.2.6 In general, the upper and lower parts of horizontally corrugated bulkheads are to be flat over a depth equal to 0,1D.

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

3.3 Bulkhead stool

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

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

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

4 Non-tight bulkheads

4.1 Non-tight bulkheads not acting as pillars

4.1.1 Non-tight bulkheads not acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- 0,9 m, for transverse bulkheads
- two frame spacings, with a maximum of 1,5 m, for longitudinal bulkheads.

4.2 Non-tight bulkheads acting as pillars

4.2.1 Non-tight bulkheads acting as pillars are to be provided with vertical stiffeners with a maximum spacing equal to:

- two frame spacings, when the frame spacing does not exceed 0,75 m,
- one frame spacing, when the frame spacing is greater than 0,75 m.

4.2.2 Each vertical stiffener, in association with a width of plating equal to 35 times the plating net thickness, is to comply with the applicable requirements for pillars in Ch 7, Sec 3, the load supported being determined in accordance with the same requirements.

4.2.3 In the case of non-tight bulkheads supporting longitudinally framed decks, vertical girders are to be provided in way of deck transverses.

5 Wash bulkheads

5.1 General

5.1.1 The requirements in [5.2] apply to transverse and longitudinal wash bulkheads whose main purpose is to reduce the liquid motions in partly filled tanks.

5.2 Openings

5.2.1 The total area of openings in a transverse wash bulkhead is generally to be between 10% and 30% of the total bulkhead area.

In the upper, central and lower portions of the bulkhead (the depth of each portion being 1/3 of the bulkhead height), the areas of openings, expressed as percentages of the corresponding areas of these portions, are to be within the limits given in Tab 1.

5.2.2 In any case, the distribution of openings is to fulfil the strength requirements specified in [4.2].

5.2.3 In general, openings may not be cut within 0,15D from bottom and from deck.

Table 1 : Areas of openings in transverse wash bulkheads

Bulkhead portion	Lower limit	Upper limit
Upper	10 %	15 %
Central	10 %	50 %
Lower	2 %	10 %