Tasneef

Emirates Classification Society

Rules for the Classification of Ships

Effective from 1 July 2024

Part E

Service Notations

www.tasneefmaritime.ae

+971 2 6922333 +971 2 4454333 info@tasneef.ae 111155, Abu Dhabi, UAE

GENERAL CONDITIONS

Definitions:

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

"**IACS**" means the International Association of Classification Societies.

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

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

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

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

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

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

"Society" or "TASNEEF" means TASNEEF Maritime

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

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

1. Society Roles

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
(i) sets forth and develops Rules.
(ii) publishes the Register of Ships.
(iii) Issues certificates, statements and reports based on its survey activities.
1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various Governments.
1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which is regulated by these general conditions unless expressly excluded in the particular contract.

2. Rule Development, Implementation and Selection of Surveyor

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published therefore, the Society, although also committed through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.
2.2. The Interested Party is required to know the Rules based on which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatement. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.
The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.
2.3. Society exercises due care and skill:
(i) In the selection of its Surveyors
(ii)In the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.
2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

3. Class Report & Interested Parties Obligation

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of the specific scope of the Service requested by the Interested Party or on its behalf.
3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as part of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorized bodies and no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties based on the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.
3.3. The classification of a Ship or the issuance of a certificate or other document connected with classification or certification and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaworthiness, structural integrity, quality or fitness for a particular purpose or service of any Ship, structure, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society about its activities reflects the condition of the Ship or the subject of certification or other activity at the time of the check.
3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, shipbuilders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

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These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, the Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.
In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.
In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third-party claim, as well as from any liability about the latter concerning the Services rendered.
Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties concerning the services rendered by the Society are described in the Rules applicable to the specific service rendered.

4. Service Request & Contract Management

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

4.2 In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested.

4.3 The contractor for the classification of a ship or for the services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30/60/90 days' notice, to be given in writing. Failure to pay, even in part, the fees due for services carried out by the society will entitled the society to immediately terminate the contract and suspend the service.
For every termination of the contract, the fees for the activities performed until the time of the termination shall be owned to the society as well as the expenses incurred in view of activities already programmed, this is without prejudice to the right to compensation due to the society as a consequence of the termination.
With particular reference to ship classification and certification, unless decided otherwise by the society, termination of the contract implies that the assignment of class to a ship is withheld or, if already assigned, that it is suspended or withdrawn, any statutory certificates issued by society will be withdrawn in those cases where provided for by agreements between the society and the flag state.

5. Service Accuracy

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

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6. Confidentiality & Document sharing

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

6.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 below, the Society's clients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific property of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.
6.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual-class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificates, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty to ensure that, whenever required, the consent of the builder is obtained about the provision of plans and drawings to the new Society, either by way of the appropriate stipulation in the building contract or by other agreement.
In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

7. Health, Safety & Environment

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

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

8. Validity of General Conditions

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

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9. Force Majeure

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

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

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

10. Governing Law and Jurisdiction

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

11. Code of Business conduct

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

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

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

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EXPLANATORY NOTE TO PART E

1. Reference edition

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

2. Amendments after the reference edition

2.1 Tasneef Rules 2000 has been completely rewritten and reorganised.

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

3. Effective date of the requirements

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

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

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

4. Rule Variations and Corrigenda

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

5. Rule subdivision and cross-references

5.1 Rule subdivision

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

Part A: Classification and Surveys

Part B: Hull and Stability

Part C: Machinery, Systems and Fire Protection

Part D: Materials and Welding

Part E: Service Notations

Part F: Additional Class Notations

Each Part consists of:

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

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

5.2 Cross-references

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

- Pt A means Part A

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

- Ch 1 means Chapter 1

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

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

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

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

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

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

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

Foreword

This edition of Part E contains amendments whose effective date is **1 July 2024**.

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

RULES FOR THE CLASSIFICATION OF SHIPS

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Part E
Service Notations

Chapter 1
RO-RO CARGO SHIPS

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 Ships complying with the requirements of this Chapter are eligible for the assignment of the service notation **ro-ro cargo ship**, as defined in Pt A, Ch 1, Sec 2, [4.2.3].

1.1.2 Ships dealt with in this Chapter are to comply with the requirements stipulated in Parts A, B, C and D, as applicable and with the requirements of this Chapter, which are specific to ro-ro cargo ships.

1.2 Summary table

1.2.1 Tab 1 indicates, for easy reference, the Sections of this Chapter dealing with requirements applicable to ro-ro cargo ships.

Table 1 *(1/1/2007)*

Main subject	Reference
Ship arrangement	**(1)**
Hull and stability	Sec 2
Machinery and cargo system	Sec 3
Electrical installations	Sec 4
Automation	**(1)**
Fire protection, detection and extinction	**(1)**

(1) No specific requirements for ro-ro cargo ships are given in this Chapter.

SECTION 2 HULL AND STABILITY

1 General

1.1 Application

1.1.1 The requirements of this Section apply to multi-deck ships with double bottom and, in some cases, with wing tanks up to the lowest deck above the full load waterline, intended for the carriage of:

- vehicles which embark and disembark on their own wheels, and/or goods in or on pallets or containers which can be loaded and unloaded by means of wheeled vehicles
- railway cars, on fixed rails, which embark and disembark on their own wheels.

1.2 Definitions

1.2.1 Ro-ro cargo spaces *(1/1/2005)*

Ro-ro cargo spaces are spaces not normally subdivided in any way and normally extending for either a substantial length or the entire length of the ship, in which motor vehicles with fuel in their tanks for their own propulsion and/or goods (packaged or in bulk, in or on rail or road cars, vehicles [including road or rail tankers], trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded normally in a horizontal direction.

1.2.2 Special category spaces *(1/1/2005)*

Special category spaces are those enclosed vehicle spaces above or below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access. Special category spaces may be arranged on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.

2 Structure design principles

2.1 General

2.1.1 Wood sheathing is recommended for caterpillar trucks and unusual vehicles.

It is recommended that a piece of wood of suitable thickness should be provided under each crutch in order to distribute the mass over the plate and the nearest stiffeners.

2.2 Hull structure

2.2.1 Framing

In general, the strength deck and the bottom are to be longitudinally framed.

Where a transverse framing system is adopted for such ships, it is to be considered by the Society on a case-by-case basis.

3 Design loads

3.1 Wheeled loads

3.1.1 The wheeled loads induced by vehicles are defined in Pt B, Ch 5, Sec 6, [6].

4 Hull girder strength

4.1 Basic criteria

4.1.1 Strength deck

In addition to the requirements in Pt B, Ch 6, Sec 1, [2.2], the contribution of the hull structures up to the strength deck to the longitudinal strength is to be assessed through a finite element analysis of the whole ship in the following cases:

- when the size of openings in side shell and/or longitudinal bulkheads located below the strength deck decreases significantly the capability of the plating to transmit shear forces to the strength deck
- when the ends of superstructures which are required to contribute to longitudinal strength may be considered not effectively connected to the hull structures.

5 Hull scantlings

5.1 Plating

5.1.1 Minimum net thicknesses

The net thickness of the weather strength deck and trunk deck plating is to be not less than the value obtained, in mm, from the following formula:

$$t = 2{,}1 + 0{,}013\ L\ k^{1/2} + 4{,}5\ s$$

where:

s : Length, in m, of the shorter side of the plate panel.

5.1.2 Deck plating in way of side doors and stern doors *(1/12/2008)*

The plating net thickness of all decks in way of the position of side doors and stern doors is to be increased over a length of at least 1/3 of the door width.

This increase in net thickness is to be not less than 50% and the resulting thickness is not required to be greater than 8,0 mm.

5.1.3 Plating under wheeled loads

The net thickness of plate panels subjected to wheeled loads is to fulfil the applicable requirements in Pt B, Ch 7, Sec 1.

5.2 Ordinary stiffeners

5.2.1 Ordinary stiffeners under wheeled loads

The strength checks of ordinary stiffeners subjected to wheeled loads are to be carried out in accordance with the applicable requirements in Pt B, Ch 7, Sec 2.

5.3 Primary supporting members

5.3.1 Primary supporting members under wheeled loads

The strength checks of primary supporting members subjected to wheeled loads are to be carried out in accordance with the applicable requirements in Pt B, Ch 7, Sec 3 and Pt B, Ch 7, App 2.

6 Other structures

6.1 Bow doors and inner doors

6.1.1 The requirements applicable to bow doors and inner doors are defined in Pt B, Ch 9, Sec 5.

6.2 Side doors and stern doors

6.2.1 Side doors and stern doors may be either below or above the freeboard deck.

6.2.2 The requirements applicable to side doors and stern doors are defined in Pt B, Ch 9, Sec 6.

6.2.3 *(1/1/2005)*

The requirements in [6.2.4] to [6.2.7] apply to doors in the boundary of ro-ro spaces and special category spaces as defined in [1.2.1] and [1.2.2] through which such spaces may be flooded.

Where no part of the door is below the uppermost waterline and the area of the door opening is not greater than 6 m^2, the requirements in [6.2.4] to [6.2.7] need not be applied.

6.2.4 Separate indicator lights and audible alarms are to be provided on the navigation bridge and on the operating panel to show that the doors are closed and that their securing and locking devices are properly positioned.

The indication panel is to be provided with a lamp test function. It is not to be possible to turn off the indicator light.

6.2.5 *(1/1/2005)*

The indicator system is to be designed on the fail-safe principle and is to show by visual alarms if the door is not fully closed and not fully locked and by audible alarms if securing devices become open or locking devices become unsecured.

The power supply for the indicator system for operating and closing doors is to be independent of the power supply for operating and closing the doors and is to be provided with a back-up power supply from the emergency source of power or other secure power supply, e.g. UPS.

The sensors of the indicator system are to be protected from water, ice formation and mechanical damage.

Note 1: The indicator system is considered designed on the fail-safe principal when the following conditions occur.

- The indication panel is provided with:
  - a power failure alarm
  - an earth failure alarm
  - a lamp test
  - separate indication for door closed, door locked, door not closed and door unlocked.
- Limit switches are electrically closed when the door is closed (when several limit switches are provided they may be connected in series).
- Limit switches are electrically closed when securing arrangements are in place (when several limit switches are provided they may be connected in series).
- Two electrical circuits (also in one multicore cable) are fitted, one for the indication of door closed / not closed and the other for door locked / unlocked.
- In the case of dislocation of limit switches, indication to show: not closed / unlocked / securing arrangement not in place - as appropriate.

6.2.6 *(1/1/2005)*

The indication panel on the navigation bridge is to be equipped with a mode selection function "harbour/sea voyage", so arranged that an audible alarm is given on the navigation bridge if the ship leaves harbour with the bow door or inner door not closed or with any of the securing devices not in the correct position.

6.2.7 *(1/7/2012)*

A water leakage detection system with audible alarm is to be arranged to provide an indication to the navigation bridge.

6.3 Movable decks and inner ramps

6.3.1 The requirements applicable to movable decks and inner ramps are defined in Pt B, Ch 9, Sec 8, [1].

6.4 External ramps

6.4.1 The requirements applicable to external ramps are defined in Pt B, Ch 9, Sec 8, [2].

7 Hull outfitting

7.1 Equipment

7.1.1 Number of mooring lines

The specific requirements in Pt B, Ch 10, Sec 4, [3.5] for ships with the service notation **ro-ro cargo ship** are to be complied with.

SECTION 3 MACHINERY

1 Application

1.1

1.1.1 *(1/7/2011)*

The requirements of item [2] apply to cargo ships of 500 gross tonnage or more.

2 Scuppers and sanitary discharges

2.1 Drainage of vehicle and ro-ro cargo spaces, intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion

2.1.1 Prevention of build-up of free surfaces *(1/7/2011)*

In cargo spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion when fixed pressure water-spraying systems are fitted, in view of the serious loss of stability which could arise due to large quantities of water accumulating on the deck or decks during the operation of the fixed pressure water-spraying system, the following arrangements are to be provided:

a) *the drainage and pumping arrangements are to be such as to prevent the build-up of free surfaces. In such case, the drainage system is to be sized to remove no less than 125% of the combined capacity of both the water-spraying system pumps and the required number of fire hose nozzles, taking into account the guidelines developed by IMO (see Note 1). The drainage system valves are to be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. Bilge wells are to be of sufficient holding capacity and are to be arranged at the side shell of the ship at a distance from each other of not more than 40 m in each watertight compartment. If this is not possible, the adverse effect upon stability of the added weight and free surface of water is to be taken into account to the extent deemed necessary by the Society in its approval of the stability information (see Note 2). Such information is to be included in the stability information supplied to the Master.* See *Pt B, Ch 3, App 2*.

b) *for closed vehicles spaces, where fixed pressure water-spraying systems are fitted, means are to be provided to prevent the blockage of drainage arrangements, taking into account the guidelines developed by IMO (see Note 1),*

Note 1: see resolution MSC.1/Circ. 1320 "Guidelines for the drainage of fire-fighting water from closed vehicle and ro-ro spaces and special category spaces of passenger and cargo ships"

Note 2: see Resolution A.123(V) "Recommendation On Fixed Fire-Extinguishing Systems For Special Category Spaces".

2.1.2 Scupper draining *(1/7/2011)*

Scuppers from cargo spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion are not to be led to machinery or other places where sources of ignition may be present.

3 Sounding pipes

3.1 General

3.1.1 *(1/7/2009)*

Requirements stipulated in Pt C, Ch 1, Sec 10, [9.2] apply except that sounding pipes used in flammable (except lubricating) oil systems may terminate in the ro-ro space on condition that the following provisions are satisfied:

a) an oil-level gauge meeting the provisions in Pt C, Ch 1, Sec 10, [2.9.2] is additionally fitted;

b) the sounding pipes terminate in locations remote from ignition hazards unless precautions are taken, such as the fitting of effective screens, to prevent the fuel oil from coming into contact with a source of ignition in the case of spillage through the terminations of the sounding pipes;

c) the terminations of sounding pipes are fitted with self-closing blanking devices and with a small diameter self-closing control cock located below the blanking device for the purpose of ascertaining before the blanking device is opened that fuel oil is not present. Provision is to be made so as to ensure that any spillage of fuel oil through the control cock involves no ignition hazard.

Where sounding pipe termination is above the bulkhead or freeboard deck, a flush type sounding head may be accepted by the Society on a case-by-case basis.

SECTION 4 ELECTRICAL INSTALLATIONS

1 General

1.1 Documentation to be submitted

1.1.1 In addition to the documentation requested in Pt C, Ch 2, Sec 1, Tab 1, the following is to be submitted for approval:

a) plan of hazardous areas

b) document giving details of types of cables and safety characteristics of the equipment installed in hazardous areas.

Table 1 : Electrical equipment permitted in closed ro-ro cargo spaces *(1/1/2022)*

Hazardous area	Spaces		Electrical equipment
	N°	Description	
Zone 1	1	Closed ro-ro cargo spaces except areas under item 3	a) any type that may be considered for zone 0 b) certified intrinsically safe apparatus Ex(ib) c) simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, junction boxes, switching devices), included in intrinsically-safe circuits of category “ib” not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules d) certified flameproof Ex(d) e) certified pressurised Ex(p) f) certified increased safety Ex(e) g) certified encapsulated Ex(m) h) certified sand filled Ex(q) i) certified specially Ex(s) j) cables sheathed with at least one of the following: • a non-metallic impervious sheath in combination with braiding or other metallic covering • copper or stainless steel sheath (for mineral-insulated cables only)

Hazardous area	Spaces		Electrical equipment
	N°	Description	
Zone 1	2	Exhaust ventilation ducts	As stated under item 1
Zone 2	3	On condition that the ventilation system is so designed and operated as to provide continuous ventilation of the cargo spaces at the rate of at least 10 air changes per hour whenever vehicles are on board: • areas above a height of 450mm from the deck • areas above a height of 450mm from each platform for vehicles, if fitted, without openings of sufficient size permitting penetration of petrol gases downward • areas above platforms for vehicles, if fitted, with openings of sufficient size permitting penetration of petrol gases downward	a) any type that may be considered for zone 1 b) tested specially for zone 2 (e.g. type “n” protection) c) pressurised d) encapsulated e) the type which ensures the absence of sparks and arcs and of “hot spots” during its normal operation (electrical equipment having an enclosure of at least IP55) f) cables sheathed with at least a non -metallic external impervious sheath

1.2 Safety characteristics

1.2.1 The explosion group and temperature class of electrical equipment of a certified safe type for use with explosive petrol-air mixtures are to be at least IIA and T3.

2 Installation

2.1 Installations in closed ro-ro cargo spaces

2.1.1 Except as provided for in [2.1.2], electrical equipment is to be of a certified safe type as stated in Pt C, Ch 2, Sec 3, [10.1.5] and electrical cables are to be as stated in Pt C, Ch 2, Sec 3, [10.2.2].

2.1.2 Above a height of 450 mm from the deck and from each platform for vehicles, if fitted, except platforms with openings of sufficient size permitting penetration of petrol gases downwards, electrical equipment as stated in Pt C, Ch 2, Sec 3, [10.1.6] and electrical cables as stated in Pt C, Ch 2, Sec 3, [10.2.3]are permitted, on condition that the ventilation system is so designed and operated as to provide continuous ventilation of the cargo spaces at the rate of at least 10 air changes per hour whenever vehicles are on board.

2.1.3 Electrical equipment and cables in an exhaust ventilation duct are to be as stated in [2.1.1].

2.1.4 The requirements in this item are summarised in Tab 1.

2.2 Installations in cargo spaces other than ro-ro cargo spaces but intended for the carriage of motor vehicles

2.2.1 The provisions of [2.1] apply.

2.2.2 All electric circuits terminating in cargo holds are to be provided with multipole linked isolating switches located outside the holds. Provision is to be made for locking in the off position.

This requirement does not apply to safety installations such as fire, smoke or gas detection systems.

3 Type approved components

3.1

3.1.1 Alarm systems for closing devices of openings and water leakage detection systems if of electronic type, as well as television surveillance systems, are to be type approved or in accordance with [3.1.2].

3.1.2 Case-by-case approval based on submission of adequate documentation and execution of tests may also be granted at the discretion of the Society.

Part E
Service Notations

Chapter 2
CONTAINER SHIPS

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 Ships complying with the requirements of this Chapter are eligible for the assignment of the service notation **container ship**, as defined in Pt A, Ch 1, Sec 2, [4.2.6].

1.1.2
Ships assigned with the additional service feature **equipped for carriage of containers** are to comply with the applicable requirements of this Chapter, in particular with Sec 2, [3.2.1], Sec 2, [3.3.1], Sec 2, [3.5.4] and Sec 2, [4.2].

1.1.3 Ships dealt with in this Chapter are to comply with the requirements stipulated in Part A, Part B, Part C and Part D, as applicable and with the requirements of this Chapter, which are specific to container ships.

1.2 Summary table

1.2.1 Tab 1 indicates, for easy reference, the Sections of this Chapter dealing with requirements applicable to container ships.

Table 1 *(1/7/2016)*

Main subject	Reference
Ship arrangement	**(1)**
Hull and stability	Sec 2
Machinery	Sec 3
Electrical installations	**(1)**
Automation	**(1)**
Fire protection, detection and extinction	**(1)**
Longitudinal strength standard for container ships	App 1

(1) No specific requirements for container ships are given in this Chapter.

SECTION 2 HULL AND STABILITY

1 General

1.1 Application

1.1.1 The requirements of this Section apply to double bottom ships of double or single side skin construction, intended to carry containers in holds or on decks. When single side skin construction is adopted, an efficient torsion box girder at the topsides or an equivalent structure is to be fitted. Typical midship sections are shown in Fig 1 and Fig 2.

The application of these requirements to other ship types is to be considered by the Society on a case-by-case basis.

Figure 1 : Container ship of double side skin construction

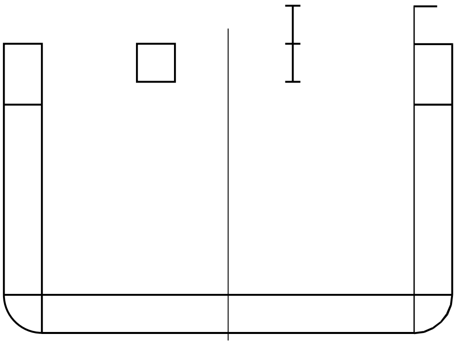
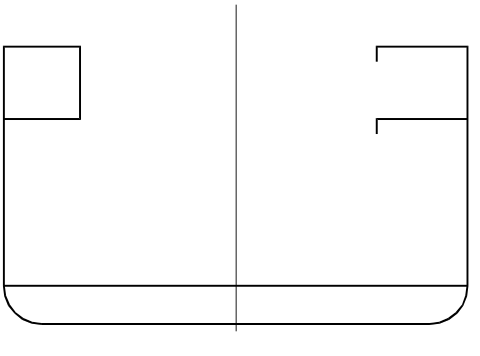


Figure 2 : Container ship of single side skin construction



2 Stability

2.1 Intact stability

2.1.1 General

The stability for the loading conditions defined in Pt B, Ch 3, App 2, [1.2.4] is to be in compliance with the requirements of Pt B, Ch 3, Sec 2.

2.1.2 Additional criteria

In addition to [2.1.1], the initial metacentric height is to be equal to or greater than 0,20 m.

2.1.3 Alternative criteria for ships greater than 100 m in length

For ships greater than 100 m in length, the Society may apply the following criteria instead of those in Pt B, Ch 3, Sec 2:

- *the area under the righting lever curve (GZ curve), in m·rad, is to be not less than 0,009/C up to an angle of heel of 30°, and not less than 0,016/C up to 40° or the angle of flooding θ_f if this angle is less than 40°*
- *the area under the righting lever curve (GZ curve), in m·rad, 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 0,006/C*
- *the righting lever GZ, in m, is to be at least 0,033/C at an angle of heel equal to or greater than 30°*
- *the maximum righting lever GZ, in m, is to be at least 0,042/C*
- *the total area under the righting lever curve (GZ curve), in m·rad, up to the angle of flooding θ_f is not to be less than 0,029/C.*

where:

C : *Coefficient defined by:*

$$C = \sqrt{\frac{T}{KG}}\sqrt{\frac{100}{L}}\left(\frac{C_B}{C_W}\right)^2\frac{TD'}{B_m^{\;2}}$$

T : *Mean draught, in m*

KG : *Height of the centre of mass above base, in m, corrected for free surface effect, not be taken as less than T*

C_B : *Block coefficient*

C_W : *Waterplane coefficient*

D' : *Moulded depth, in m, corrected for defined parts of volumes within the hatch coamings obtained from the following formula:*

$$D' = D + \left(\frac{2b - B_D}{B_D}\right)\left(\frac{2\Sigma\ell_H}{L}\right)h$$

h : *Mean height, in m, of hatch coamings within L/4 forward and aft from amidships (see Fig 3)*

b : *Mean width, in m, of hatch coamings within L/4 forward and aft from amidships (see Fig 3)*

B_m, B_D : *Breadths, in m, defined in Fig 3*

ℓ_H : *Length, in m, of each hatch coaming within L/4 forward and aft from amidships (see Fig 4).*

Figure 3 : Definition of dimensions

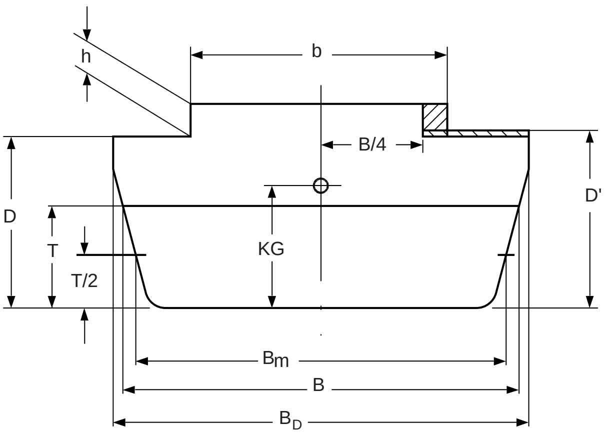
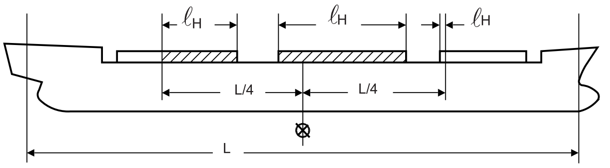


Figure 4 : Definition of dimensions



2.1.4 Additional requirements for open top container ships *(1/10/2005)*

Intact stability calculations are to be investigated for the ship in the intact condition and considering the effect of the ingress of green water through the open hatchways in the following way*:*

- *for the intact condition described in [2.1.5] with the assumptions in [2.1.6], the stability of the ship is to comply with the survival criteria of Pt F, Ch 13, Sec 11: the factor of survival "s" is to be equal to one.*

2.1.5 Loading condition for open top container ships

The ship is at the load line corresponding to the minimum freeboard assigned to the ship and, in addition, all the open holds are completely filled with water, with a permeability of 0,70 for container holds, to the level of the top of the hatch side or hatch coaming or, in the case of a ship fitted with cargo hold freeing ports, to the level of those ports.

Intermediate conditions of flooding the open holds (various percentages of filling the open holds with green water) are to be investigated.

2.1.6 Assumptions for the stability calculation for open top container ships

Where cargo hold freeing ports are fitted, they are to be considered closed for the purpose of determining the flooding angle, provided that the reliable and effective control of closing of these freeing ports is to the satisfaction of the Society.

For the condition with flooded holds relevant to the intact ship, the free surfaces may be determined as follows:

- *the holds are fully loaded with containers*
- *the sea water enters the containers and will not pour out during heeling, condition simulated by defining the amount of water in the containers as fixed weight items*
- *the free space surrounding the containers is to be flooded with sea water*
- *the free space is to be evenly distributed over the full length of the open cargo holds.*

3 Structure design principles

3.1 Materials

3.1.1 Steels for hull structure

The material classes required in Pt B, Ch 4, Sec 1, [2.4] for the strength deck plating, the sheerstrake and the torsion box girder structure within 0,4L amidships are to be maintained in way of the entire cargo hold region.

3.2 Strength principles

3.2.1 General

Local reinforcements of the hull structure are to be provided under container corners and in way of cell guides, if fitted.

3.2.2 Structural continuity

In double side skin ships, where the machinery space is located between two holds, the inner side is, in general, to be continuous within the machinery space. Where the machinery space is situated aft, the inner side is to extend as far abaft as possible and be tapered at the ends.

3.3 Bottom structure

3.3.1 Floor and girder spacing

The floor spacing is to be such that floors are located in way of the container corners. Floors are also to be fitted in way of watertight bulkheads.

Girders are generally to be fitted in way of the container corners.

3.3.2 Reinforcements in way of cell guides

The structures of the bottom and inner bottom on which cell guides rest are to be adequately stiffened with doublers, brackets or other equivalent reinforcements.

3.4 Side structure

3.4.1 Framing arrangement

The topside torsion box girders are to be longitudinally framed.

Where the side is longitudinally framed, side transverses are to be fitted in line with the double bottom floors.

3.5 Deck structure

3.5.1 Longitudinal girders between hatchways

The width of the longitudinal deck girders and hatch coaming flanges is to be such as to accommodate the hatch covers and their securing arrangements.

The connections of the longitudinal deck girders and hatch coamings with the machinery space structure, and aft and fore part structures are to ensure proper transmission of stresses from the girders to the adjacent structures.

3.5.2 Cross decks

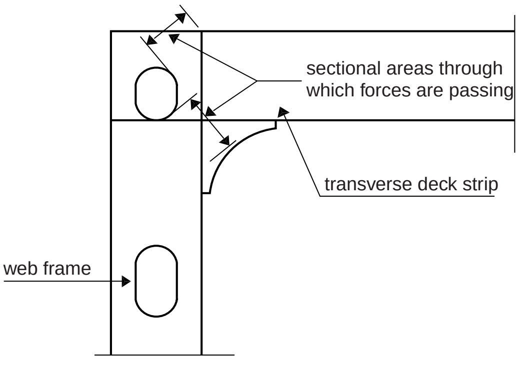
Side or centreline longitudinal deck girders transmit the following longitudinal forces to transverse deck strips: forces due to hull girder bending and forces due to local bending of the girders.

When the arrangement of hatches involves the interruption of girders (a ship with two side hatches in one hold and a centreline hatch in the adjacent one), the transverse strip between the two holds is to be able to bear the longitudinal force exerted by the interrupted girder. Calculation of the strength of these strips is to be made.

Transverse deck strips between hatches are also subjected to a shear force induced by the overall torsion of the ship. The adequate strength of these strips is to be verified also taking account of this force.

Transverse deck strips between hatches are to be suitably overlapped at ends. It is necessary to ascertain that the forces induced by the strips may be transmitted to the web frame (see Fig 5).

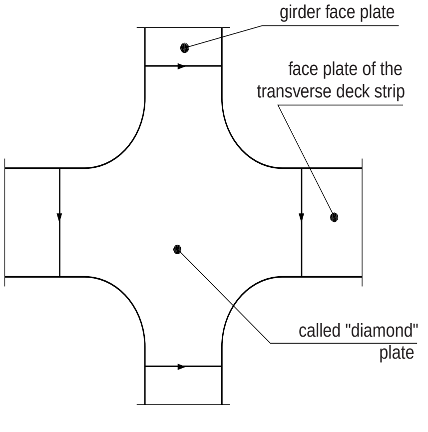
Figure 5 : Transverse deck strip between hatches



3.5.3 Connection of longitudinal deck girders between hatchways with face plate of cross decks

Where longitudinal deck girders between hatchways intersect cross decks, the connection between their face plates is generally to be as shown in Fig 6. If necessary, the girder height is to be gradually modified.

Figure 6 : Connection of longitudinal girders between hatchways with face plates of cross decks



3.5.4 Deck and hatch cover reinforcements

Deck or hatch cover structures are to be reinforced taking into account the loads transmitted by the corners of containers and cell guides.

3.6 Bulkhead structure

3.6.1 Transverse box structures in way of transverse watertight bulkheads

Bottom and top transverse box structures are generally to be provided in way of transverse watertight bulkheads at the inner bottom and deck level, respectively.

3.6.2 Primary supporting members

The vertical primary supporting members of transverse watertight bulkheads are to be fitted in line with the deck girders and the corresponding bottom girders.

3.6.3 Reinforcements in way of cell guides

When cell guides are fitted on transverse or longitudinal bulkheads which form boundaries of the hold, such structures are to be adequately reinforced taking into account the loads transmitted by cell guides.

4 Design loads

4.1 Hull girder loads

4.1.1 Still water loads

The design still water torsional torque induced by the non-uniform distribution of cargo, consumable liquids and ballast is to be considered. If no specific data are provided by the Designer, it is to be obtained at any hull transverse section, in kN.m, from the following formula:

$$M_{SW,T} = 31{,}4 F_T S T B$$

where:

- F_T : Distribution factor defined in Tab 1 as a function of the x co-ordinate of the hull transverse section with respect to the reference co-ordinate system defined in Pt B, Ch 1, Sec 2, [4]
- S : Number of container stacks over the breadth B
- T : Number of container tiers in cargo hold amidships (excluding containers on deck or on hatch covers).

Where the value of $M_{SW,T}$ obtained from the above formula is greater than 49000 kN.m, the Society may require more detailed calculations of $M_{SW,T}$ to be carried out by the Designer.

Table 1 : Distribution factor F_T

Hull transverse section location	Distribution factor F_T
$0 \le x < 0,5L$	x / L
$0,5L \le x \le L$	$(1 - x / L)$

4.2 Forces on containers

4.2.1 Still water and inertial forces

The still water and inertial forces applied to one container located at the level "i", as defined in Fig 7, are to be obtained, in kN, as specified in Tab 2.

Where empty containers are stowed at the top of a stack, the internal pressures and forces are to be calculated considering mass of empty containers equal to:

- 0,14 times the mass of a loaded container, in the case of steel containers
- 0,08 times the mass of a loaded container, in the case of aluminium containers

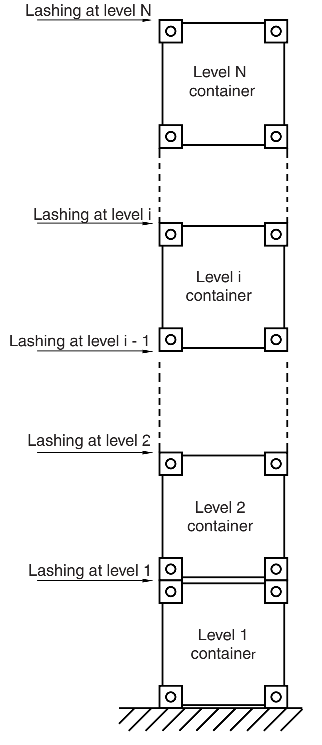
Table 2 : Container at level "i" Still water and inertial forces

Ship condition	Load case	Still water force F_S and inertial force F_W , in kN
Still water		$F_{S,i} = M_i g$
Upright (positive heave motion)	"a"	No inertial force
	"b"	$F_{W,X,i} = M_i a_{X1}$ in x direction $F_{W,Z,i} = -M_i a_{Z1}$ in z direction
Inclined (negative roll angle)	"c"	$F_{W,Y,i} = M_i C_{FA} a_{Y2}$ in y direction
	"d"	$F_{W,Z,i} = M_i C_{FA} a_{Z2}$ in z direction

Note 1:

- g : Gravity acceleration, in m/s²: g = 9,81 m/s²
- M_i : Mass, in t, of the container considered at the level "i"
- C_{FA} : Combination factor, to be taken equal to:
  - $C_{FA} = 0,7$ for load case "c"
  - $C_{FA} = 1,0$ for load case "d"
- a_{X1}, a_{Z1} : Accelerations, in m/s², determined at the container's centre of gravity for the upright ship condition, and defined in Pt B, Ch 5, Sec 3, [3.4]
- a_{Y2}, a_{Z2} : Accelerations, in m/s², determined at the container's centre of gravity for the inclined ship condition, and defined in Pt B, Ch 5, Sec 3, [3.4].

Figure 7 : Containers level in a stack



4.2.2 Wind forces applied to one container

The forces due to the effect of the wind, applied to one container stowed above deck at the level "i", are to be obtained, in kN, from the following formulae:

- in x direction:
  $F_{x,wind,i} = 1,2 h_C b_C$
- in y direction:
  $F_{y,wind,i} = 1,2\ h_C \ell_C$

where:

- h_C : Height, in m, of a container
- ℓ_C, b_C : Dimension, in m, of the container stack in the ship longitudinal and transverse direction, respectively.

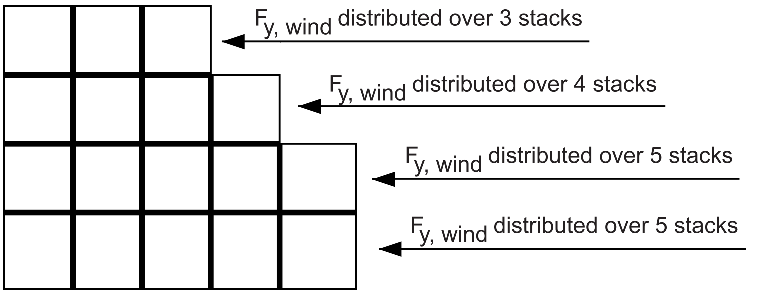
These forces are only acting on the stack exposed to wind. In the case of M juxtaposed and connected stacks of the same height, the wind forces are to be distributed over the M stacks.

In the case of juxtaposed and connected stacks of different heights, the wind forces are to be distributed taking into account the number of stacks at the level considered (see example in Fig 8).

4.2.3 Stacks of containers

The still water, inertial and wind forces, to be considered as being applied at the centre of gravity of the stack, and those transmitted at the corners of such stack are to be obtained, in kN, as specified in Tab 3.

Figure 8 : Distribution of wind forces in the case of stacks of different heights



4.2.4 Effect of cell guides

Where cell guides support the containers stowed in holds, the values of $R_{W,1}$ and $R_{W,2}$ calculated according to [4.2.3] for inclined ship condition, may be assumed to be not greater than ($F_{W,Z}$ / 4 + 160), provided that arrangements of cell guides and horizontal transverse cross-ties, according to [10.2], ensure the blocking of the corners of containers.

Any other arrangement may be accepted, to the Society's satisfaction.

5 Yielding checks

5.1

5.1.1 *(1/7/2016)*

The requirements in App 1, [4] are to be applied in addition of those indicated in Pt B, Ch 6, Sec 2.

6 Buckling check

6.1

6.1.1 *(1/7/2016)*

The requirements in App 1, [5] are to be applied to plate panels and ordinary stiffeners subjected to hull girder bending and shear stresses in addition of those given in Pt B, Ch 7, Sec 1, [5] and. Pt B, Ch 7, Sec 2, [5].

7 Ultimate strength check

7.1

7.1.1 *(1/7/2016)*

The requirements in App 1, [6] are to be applied in lieu of those indicated in Pt B, Ch 6, Sec 3.

8 Hull scantlings

8.1 Plating

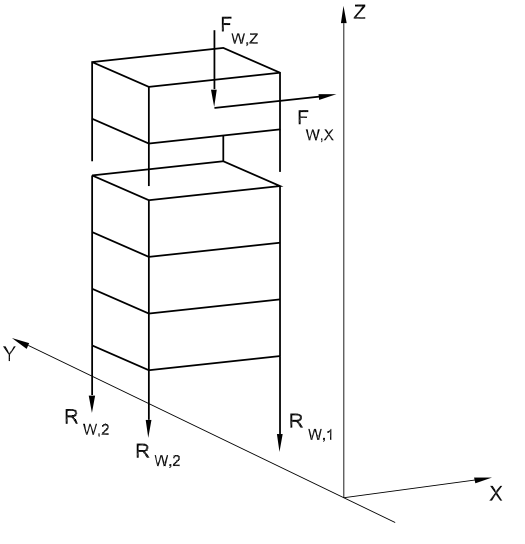
8.1.1 Thickness of the strake below the sheerstrake

The thickness of the strake below the sheerstrake may not be less than 0,7 times that of the sheerstrake.

8.1.2 Thickness of the strake below the upper strake of torsion box girders

The thickness of the strake below the upper strake of torsion box girders may not be less than 0,7 times that of the upper strake.

Figure 9 : Inertial and wind forces
Upright ship condition



8.2 Primary supporting members

8.2.1 Scantlings of primary supporting members of ships greater than 150 m in length are to be analysed according to Pt B, Ch 7, App 3, as deemed necessary by the Society on a case-by-case basis.

9 Other structures

9.1 Non-weathertight hatch covers above superstructure deck

9.1.1 Non-weathertight hatch covers may be fitted to hatchways located on weather decks which are at least two standard heights of superstructure above the assumed freeboard deck. Where any part of a hatchway is forward of a point located one quarter of the ship's length (0,25L) from the forward perpendicular, that hatchway is to be located on a weather deck at least three standard heights of superstructure above the actual or assumed freeboard deck.

The assumed freeboard deck is used only for the purpose of measuring the height of the deck on which the hatchways are situated. The assumed freeboard deck may be an actual freeboard deck or a virtual deck from which a freeboard can be calculated resulting in a draught not less than that corresponding to the freeboard actually assigned.

Figure 10 : Inertial and wind forces Inclined ship condition

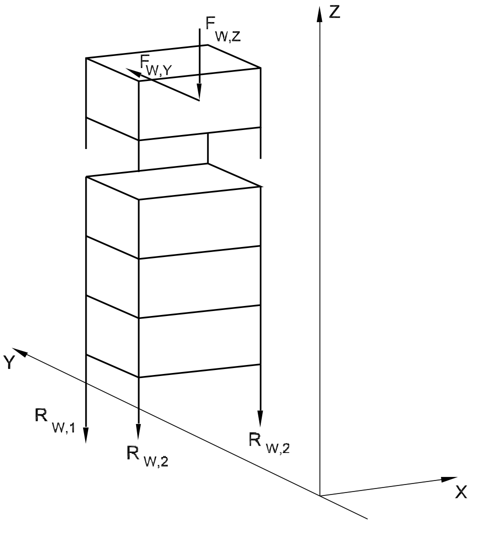


Table 3 : Containers - Still water, inertial and wind forces

Ship condition	Load case	Still water force F_S and inertial and wind force F_W, in kN, acting on each container stack	Vertical still water force R_S and inertial and wind force R_W, in kN, transmitted at the corners of each container stack
Still water condition		$F_S = \sum_{i=1}^{N} F_{S,i}$	$R_S = \frac{F_S}{4}$
Upright condition (see Fig 9)	"a"	No inertial forces	No inertial forces
	"b"	• in x direction $F_{W,X} = \sum_{i=1}^{N} (F_{W,X,i} + F_{X,wind,i})$ • in z direction $F_{W,Z} = \sum_{i=1}^{N} F_{W,Z,i}$	$R_{W,1} = \frac{F_{W,Z}}{4} + \frac{N_C h_C F_{W,X}}{4\ell_C}$ $R_{W,2} = \frac{F_{W,Z}}{4} - \frac{N_C h_C F_{W,X}}{4\ell_C}$
Inclined condition (negative roll angle) (see Fig 10)	"c" and "d"	• in y direction $F_{W,Y} = \sum_{i=1}^{N} (F_{W,Y,i} + F_{Y,wind,i})$ • in z direction $F_{W,Z} = \sum_{i=1}^{N} F_{W,Z,i}$	$R_{W,1} = \frac{F_{W,Z}}{4} + \frac{N_C h_C F_{W,Y}}{4b_C}$ $R_{W,2} = \frac{F_{W,Z}}{4} - \frac{N_C h_C F_{W,Y}}{4b_C}$

Note 1:
N : Number of containers per stack
h_C : Height, in m, of a container
ℓ_C, b_C : Dimension, in m, of the container stack in the ship longitudinal and transverse direction, respectively.

9.1.2 The hatchway coamings are to be not less than 600 mm in height.

9.1.3 The non-weathertight gaps between hatch cover panels are to be considered as unprotected openings with respect to the requirements of intact and damage stability calculations.

The non-weathertight gaps between hatch cover panels are to be as small as possible commensurate with the capacity of the bilge system and expected water ingress, and the capacity and operational effectiveness of the fire-fighting system and, in general, less than 50 mm.

9.1.4 Labyrinths, gutter bars or equivalent are to be fitted near the edges of each panel in way of the gaps to minimise the amount of water that can enter the container hold from the top surface of each panel.

9.1.5 Scantlings of the hatch cover panels as well as details of the securing arrangements for the supporting structure and coamings are to be equivalent to those for weathertight covers, and are to be obtained in accordance with the applicable requirements of Pt B, Ch 9, Sec 7.

10 Fixed cell guides

10.1 General

10.1.1 Containers may be secured within fixed cell guides, permanently connected by welding to the hull structure, which prevent horizontal sliding and tipping (see Fig 11).

10.1.2 When containers are secured by fixed cell guides, the scantlings of such cell guides and supports are to be approved and checked using the criteria in [10.2] and [10.3].

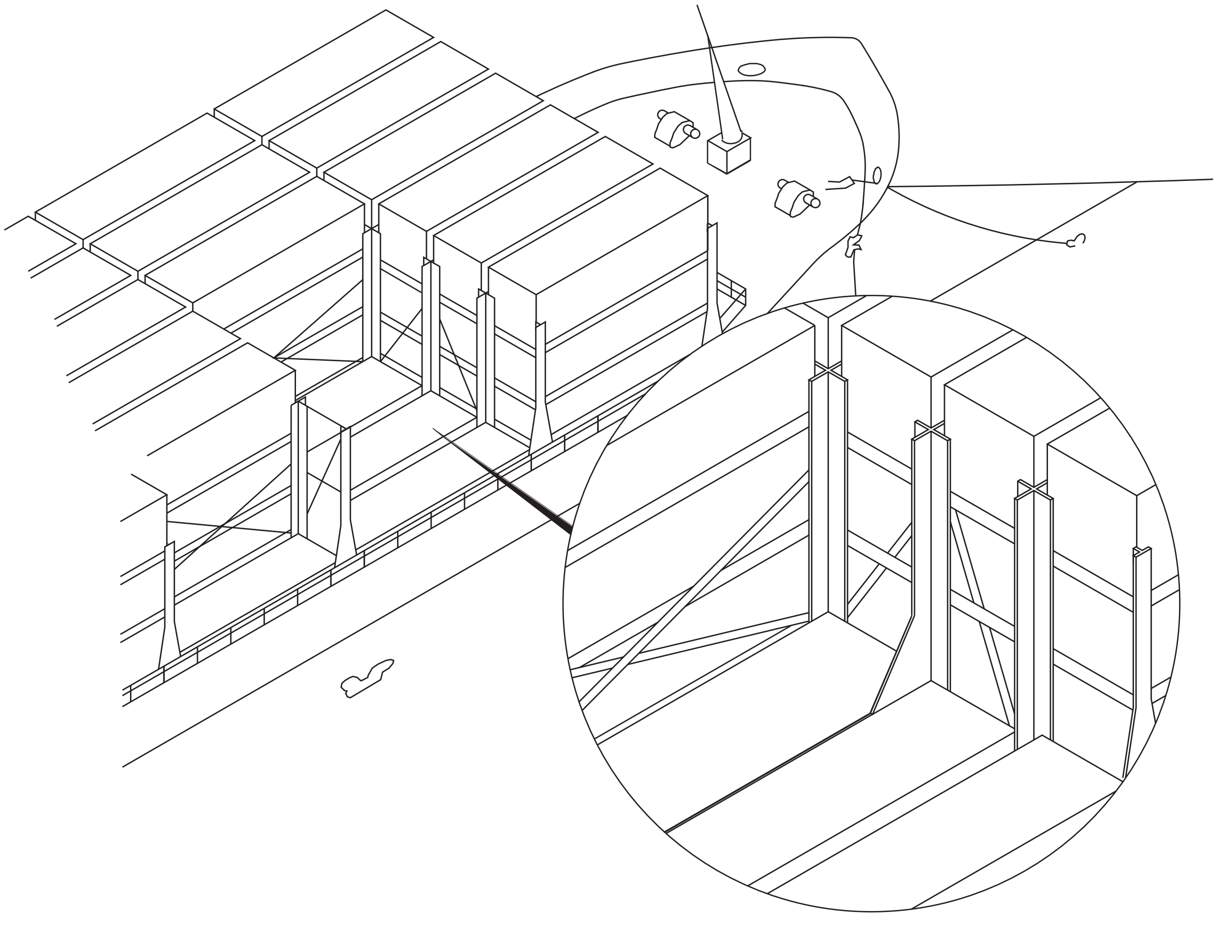
10.2 Arrangement of fixed cell guides

10.2.1 Vertical guides generally consist of sections with equal sides, not less than 12 mm in thickness, extended for a height sufficient to give uniform support to containers.

10.2.2 Guides are to be connected to each other and to the supporting structures of the hull by means of cross-ties and longitudinal members such as to prevent deformation due to the action of forces transmitted by containers.

In general, the spacing between cross-ties connecting the guides may not exceed 5 metres, and their position is to coincide as nearly as possible with that of the container corners (see Fig 12).

Figure 11 : Containers within fixed cell guides



Cross-ties are to be longitudinally restrained at one or more points so that their elastic deformation due to the action of the longitudinal thrust of containers does not exceed 20 mm at any point.

10.2.3 In stowing containers within the guides, the maximal clearance between container and guide is not to exceed 25 mm in the transverse direction and 38 mm in the longitudinal direction.

10.2.4 The upper end of the guides is to be fitted with a block to facilitate entry of the containers. Such appliance is to be of robust construction so as to withstand impact and chafing.

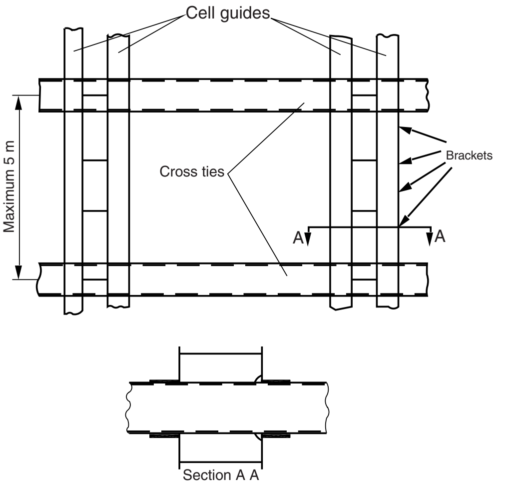
10.3 Strength criteria

10.3.1 The local stresses in the elements of cell guides, transverse and longitudinal cross-ties, and connections with the hull structure are to be less than the following values:

- normal stress: 150/k N/mm^2
- shear stress: 100/k N/mm^2
- von Mises equivalent stress: 175/k N/mm^2,

where k is the material factor, defined in Pt B, Ch 4, Sec 1, [2.3].

Figure 12 : Typical structure of cell guides



11 Construction and testing

11.1 Special structural details

11.1.1 The specific requirements in Pt B, Ch 12, Sec 2, [2.7] for ships with the service notation **container ship** are to be complied with.

SECTION 3 MACHINERY

1 Open top container ships

1.1

1.1.1 *(1/1/2007)*

The bilge system arrangements of open top container ships are to comply with the relevant requirements of IMO MSC/Circ.608/rev.1 “Interim guidelines for open top container ships”.

APPENDIX 1 LONGITUDINAL STRENGTH STANDARD FOR CONTAINER SHIPS

Symbols

T : Scantling draught, in m

C_B : Block coefficient at scantling draught

C_W : Waterplane coefficient at scantling draught, to be taken as:

$$C_W = \frac{A_W}{(LB)}$$

where L is rule length as defined in Pt B, Ch 1, Sec 2, [3.1] and B is moulded breadth as defined in Pt B, Ch 1, Sec 2, [3.4]

A_W : Waterplane area at scantling draught, in m^2

C : Wave parameter defined in [3.2]

M_{SW} : Vertical still water bending moment in seagoing condition, in kNm, at the cross section under consideration, as defined in [3.1.1]

M_{SWmax} : Permissible maximum vertical still water bending moments in seagoing condition, in kNm, at the cross section under consideration, see [3.1.2]

M_{SWmin} : Permissible minimum vertical still water bending moments in seagoing condition, in kNm, at the cross section under consideration, see [3.1.2]

M_{WV} : Vertical wave bending moment in seagoing condition, in kNm, at the cross section under consideration, as defined in [3.2.2]

Q_{SW} : Vertical still water shear force in seagoing condition, in KN, at the cross section under consideration as defined in [3.1.1]

Q_{SWmax} : Permissible maximum still water vertical shear forces in seagoing condition, in KN, at the cross section under consideration, see [3.1.2]

Q_{SWmin} : Permissible minimum still water vertical shear forces in seagoing condition, in KN, at the cross section under consideration, see [3.1.2]

Q_{WV} : Vertical wave shear force in seagoing condition, in KN, at the cross section under consideration, as defined in [3.2.3]

t_n : Net thickness, in mm, defined in [2.1]

R_{eH} : Specified minimum yield stress of the material in N/mm^2

k : Material factor, as defined in Pt B, Ch 4, Sec 1, [2.3]

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

- for steels in general:

  $E = 2{,}06 \cdot 10^5$ N/mm^2

- for stainless steels:

  $E = 1{,}95 \cdot 10^5$ N/mm^2

- for aluminium alloys:

  $E = 7{,}0 \cdot 10^4$ N/mm^2

ν : Poisson's ratio. Unless otherwise specified, a value of 0,3 is to be considered

z : Z coordinate, in m, of the calculation point with respect to the reference co-ordinate system defined in Pt B, Ch 1, Sec 2, [4]

σ_1 : Hull girder bending stress, in N/mm^2, defined in [3.4.1]

τ_1 : Hull girder shear stress, in N/mm^2, defined in [3.4.2]

R_{eH_S} : Specified minimum yield stress of the stiffeners, in N/mm^2

R_{eH_P} : Specified minimum yield stress of the plate, in N/mm^2

a : Length of the longer side of the plate panel as shown in Tab 6, in mm

b : Length of the shorter side of the plate panel as shown in Tab 6, in mm

d : Length of the side parallel to the axis of the cylinder corresponding to the curved plate panel as shown in Tab 7, in mm

ℓ : Span, in mm, of ordinary stiffeners equal to the spacing between primary supporting members

s : Spacing of stiffeners, in mm, to be taken as the mean spacing between the stiffeners of the considered stiffened panel

R : Radius of curved plate panel, in mm

t_P : Net thickness, in mm, of plate panel

h_W : Web height, in mm, of an ordinary stiffener

t_W : Web net thickness, in mm, of an ordinary stiffener

b_f : Face plate width, in mm, of an ordinary stiffener

t_f : Face plate net thickness, in mm, of an ordinary stiffener

σ_E : Elastic buckling reference stress, in N/mm^2, obtained from the following formulae:

- For the application of plate limit state according to [5.5.1]:

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_p}{b}\right)^2$$

- For the application of curved plate panels according to [5.6.1]:

$$\sigma_E = \frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t_p}{d}\right)^2$$

1 General

1.1 Application

1.1.1 Application *(1/7/2016)*

The requirements of this Appendix apply to ships with the service notation **container ship** with a length L of 90 m and greater and operated in unrestricted service.

1.1.2 Load limitations *(15/4/2019)*

The wave induced load requirements apply to monohull displacement ships in unrestricted service and are limited to ships meeting the following criteria:

- 90 m $\leq L \leq$ 500 m
- 5 $\leq L/B \leq$ 9
- 2 $\leq B/T \leq$ 6
- 0,55 $\leq C_B \leq$ 0,9

For ships that do not meet all of the aforementioned criteria, special considerations such as direct calculations of wave induced loads may be required by the Society.

1.1.3 Longitudinal extent of strength assessment *(1/7/2016)*

The stiffness, yield strength, buckling strength and hull girder ultimate strength assessment are to be carried out in way of 0,2L to 0,75L with due consideration given to locations where there are significant changes in hull cross section, e.g. changing of framing system and the fore and aft end of the forward bridge block in case of two-island designs.

In addition, strength assessments are to be carried out outside this area. As a minimum assessments are to be carried out at forward end of the foremost cargo hold and the aft end of the aft most cargo hold. Evaluation criteria used for these assessments will be determined by the Society on a case-by-case basis.

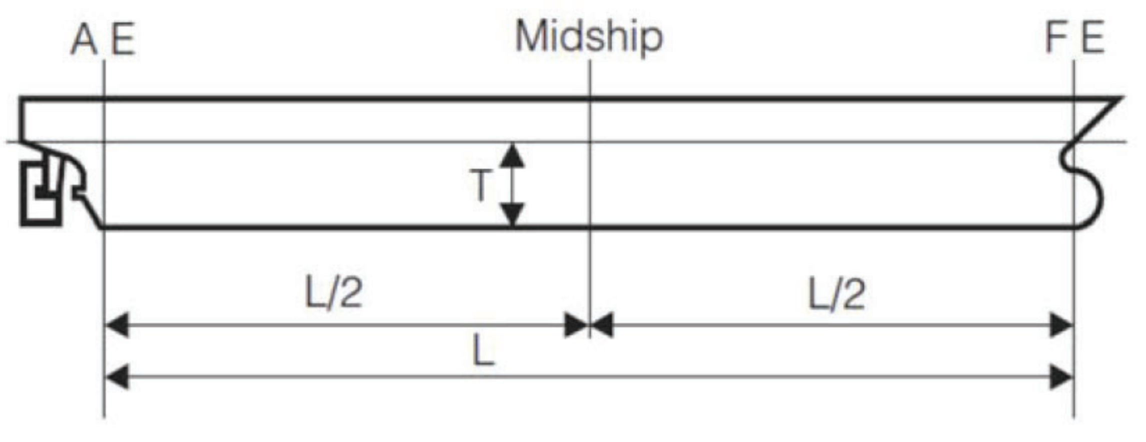
1.2 Definitions

1.2.1 Force and aft end *(1/7/2016)*

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

Figure 1 : End of length L *(1/7/2016)*



2 Structure design principles

2.1 Corrosion margin and net thickness

2.1.1 Net scantling definitions *(15/4/2019)*

The strength is to be assessed using the net thickness approach on all scantlings.

The net thickness t_n, in mm, for the plates, webs and flanges is obtained from the following formula:

$t_n = t_{as\_built} - t_{vol\_add} - \alpha\, t_c$

where:

t_{as_built} : as built thickness, in mm

t_{vol_add} : voluntary addition, in mm

α : corrosion addition factor, whose value are defined in Tab 1

t_c : corrosion addition, in mm, defined in

Table 1 : Values of corrosion addition factor *(15/4/2019)*

Structural requirement	Property / analysis type	α
Strength assessment (see [4])	Section properties	0,5
Hull girder buckling strength (see [5])	Section properties (stress determination)	0,5
	Buckling capacity	1,0
Hull girder ultimate strength (see [6])	Section properties	0,5
	Buckling / collapse capacity	0,5

2.1.2 Determination of corrosion addition *(15/4/2019)*

The corrosion addition for each of the two sides of a structural member, t_{c1} or t_{c2} is specified in Tab 2. The total corrosion addition, t_c, in mm, for both sides of the structural member is obtained by the following formula:

$$t_c = (t_{c1} + t_{c2}) + t_{res}$$

where:

t_{res} is the reserve thickness to be taken as 0,5 mm.

For an internal member within a given compartment, the total corrosion addition, t_c is obtained from the following formula:

$$t_c = (2t_{c1}) + t_{res}$$

The corrosion addition of a stiffener is to be determined according to the location of its connection to the attached plating.

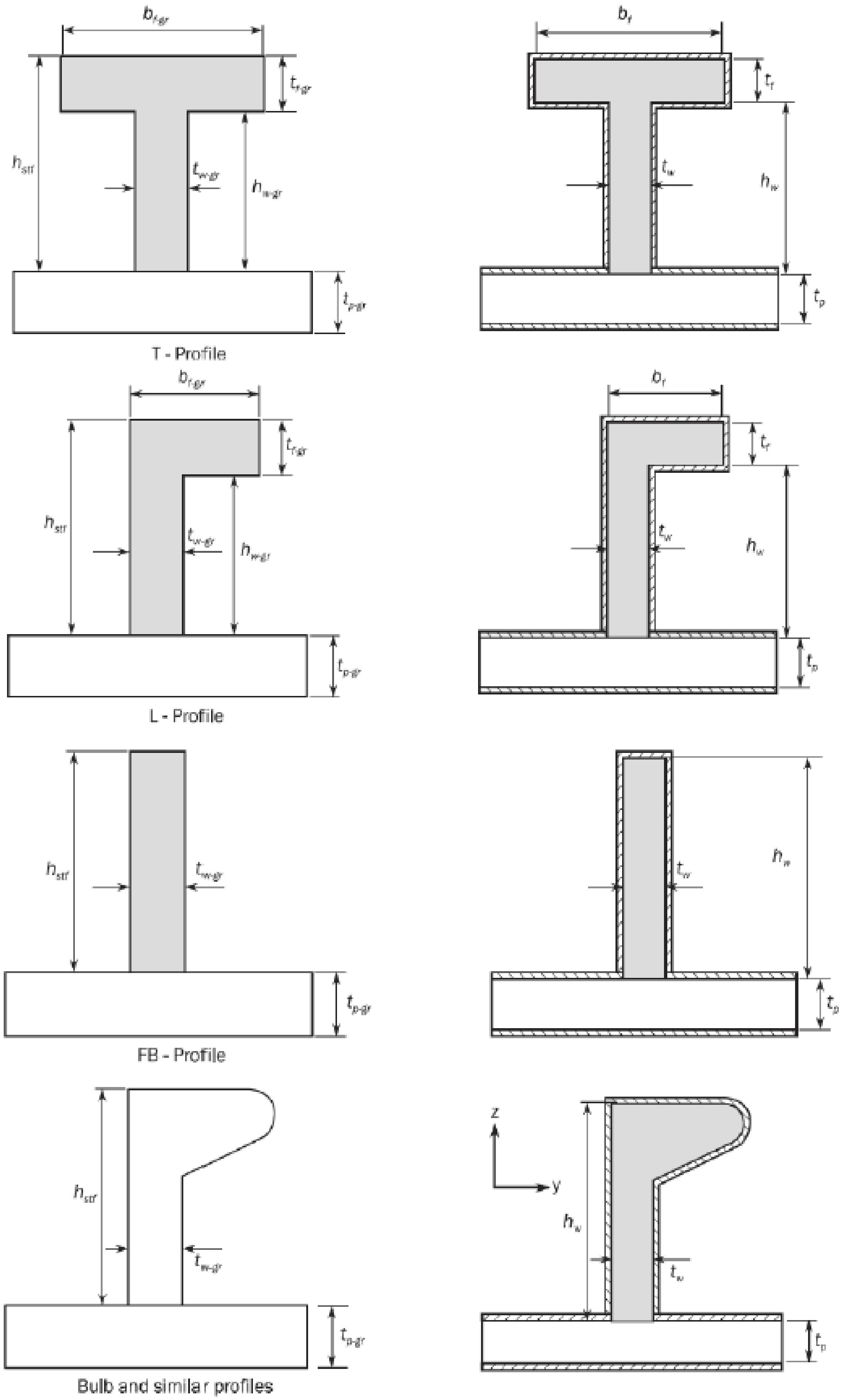
Table 2 : Corrosion addition for one side of a structural member *(1/7/2016)*

Compartment type	One side corrosion addition t_{c1} or t_{c2} [mm]
Exposed to sea water	1,0
Exposed to atmosphere	1,0
Ballast water tank	1,0
Void and dry spaces	0,5
Fresh water, fuel oil and lube oil tank	0,5
Accommodation spaces	0,0
Container holds	1,0
Compartment types not mentioned above	0,5

2.1.3 Determination of net section properties *(1/7/2016)*

The net section modulus, moment of inertia and shear area properties of a supporting member are to be calculated using the net dimensions of the attached plate, web and flange, as defined in Fig 2. The net cross-sectional area, the moment of inertia about the axis parallel to the attached plate and the associated neutral axis position are to be determined through applying a corrosion magnitude of 0,5 αt_c deducted from the surface of the profile cross-section.

Figure 2 : Net sectional properties of supporting members *(1/7/2016)*



3 Design loads

3.1 Hull girder still water loads

3.1.1 General *(1/7/2016)*

Still water bending moments, M_{SW} in kNm, and still water shear forces, Q_{SW} in kN, are to be calculated at each section along the ship length for design loading conditions as specified in [3.1.2].

3.1.2 Design loading conditions *(1/7/2016)*

In general, the design cargo and ballast loading conditions, based on amount of bunker, fresh water and stores at departure and arrival, are to be considered for the M_{SW} and Q_{SW} calculations. Where the amount and disposition of consumables at any intermediate stage of the voyage are considered more severe, calculations for such intermediate conditions are to be submitted in addition to those for departure and arrival conditions.

Also, where any ballasting and/or de-ballasting is intended during voyage, calculations of the intermediate condition just before and just after ballasting and/or de-ballasting any ballast tank are to be submitted and where approved included in the loading manual for guidance.

The permissible vertical still water bending moments M_{SWmax} and M_{SWmin} and the permissible vertical still water shear forces Q_{SWmax} and Q_{SWmin} in seagoing conditions at any longitudinal position are to envelop:

- The maximum and minimum still water bending moments and shear forces for the seagoing loading conditions defined in the Loading Manual.
- The maximum and minimum still water bending moments and shear forces specified by the designer.

The Loading Manual should include the relevant loading conditions, which envelop the still water hull girder loads for seagoing conditions, including those specified in the following (subdivided into departure and arrival conditions):

- Homogeneous loading conditions at maximum draught
- Ballast conditions
- Special loading conditions, e.g. container conditions at less than the maximum draught, empty holds, etc., as applicable
- Short voyage or harbour conditions, where applicable
- Docking condition afloat
- Loading and unloading transitory conditions, where applicable.

3.2 Hull girder wave loads

3.2.1 Wave parameter *(15/4/2019)*

The wave parameter is defined as follows:

$$C = 1 - 1,50\left(1 - \sqrt{\frac{L}{L_{ref}}}\right)^{2,2} \text{for } L \le L_{ref}$$

$$C = 1 - 0,45\left(\sqrt{\frac{L}{L_{ref}}} - 1\right)^{1,7} \text{for } L > L_{ref}$$

where:

L_{ref} : Reference length, in m, to be taken as:

- $L_{ref} = 315\ C_W^{-1,3}$ for the determination of vertical wave bending moments according to [3.2.2]
- $L_{ref} = 330\ C_W^{-1,3}$ for the determination of vertical wave shear moments according to [3.2.3].

3.2.2 Vertical wave bending moments *(15/4/2019)*

The distribution of the vertical wave bending moments, M_{WV} in KNm, along the ship length is given in Fig 4, where:

$$M_{WV,H} = 1,5 f_R L^3 C C_W \left(\frac{B}{L}\right)^{0,8} f_{NL-Hog}$$

$$M_{WV,S} = -1,5 f_R L^3 C C_W \left(\frac{B}{L}\right)^{0,8} f_{NL-Sag}$$

where:

f_R : Factor related to the operational profile to be taken equal to 0,85

f_{NL-Hog} : Non-linear correction for hogging, to be taken as:

$$f_{NL-Hog} = 0,3\frac{C_B}{C_W}\sqrt{T}$$

not to be taken greater than 1,1

f_{NL-Sag} : Non-linear correction for sagging, to be taken as:

$$f_{NL-Sag} = 4,5\frac{1 + 0,2 f_{Bow}}{C_W \sqrt{C_B} L^{0,3}}$$

not to be taken less than 1,0

f_{Bow} : Bow flare shape coefficient, to be taken as:

$$f_{Bow} = \frac{A_{DK} - A_{WL}}{0,2 L z_f}$$

A_{DK} : Projected area in horizontal plane of uppermost deck, in m^2 including the forecastle deck, if any, extending from 0,8L forward (see Fig 3). Any other structures, e.g. plated bulwark, are to be excluded.

A_{WL} : Waterplane area, in m^2, at draught T, extending from 0,8L forward

z_f : Vertical distance, in m, from the waterline at draught T to the uppermost deck (or forecastle deck), measured at FE (see Fig 3). Any other structures, e.g. plated bulwark, are to be excluded.

3.2.3 Vertical wave shear forces *(15/4/2019)*

The distribution of the vertical wave shear forces, Q_{WV} in kN, along the ship length is given in Fig 5, where:

$$Q_{WV,H}^{Aft} = 5,2 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0,8} (0,3 + 0,7 f_{NL-Hog})$$

$$Q_{WV,H}^{Fore} = -5,7 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0,8} f_{NL-Hog}$$

$$Q_{WV,S}^{Aft} = -5,2 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0,8} (0,3 + 0,7 f_{NL-Sag})$$

$$Q_{WV}^{Mid} = 4,0 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0,8}$$

$$Q_{WV,S}^{Fore} = 5,7 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0,8} (0,25 + 0,75 f_{NL-Sag})$$

Figure 3 : Projected area A_{DK} and vertical distance z_f *(1/7/2016)*

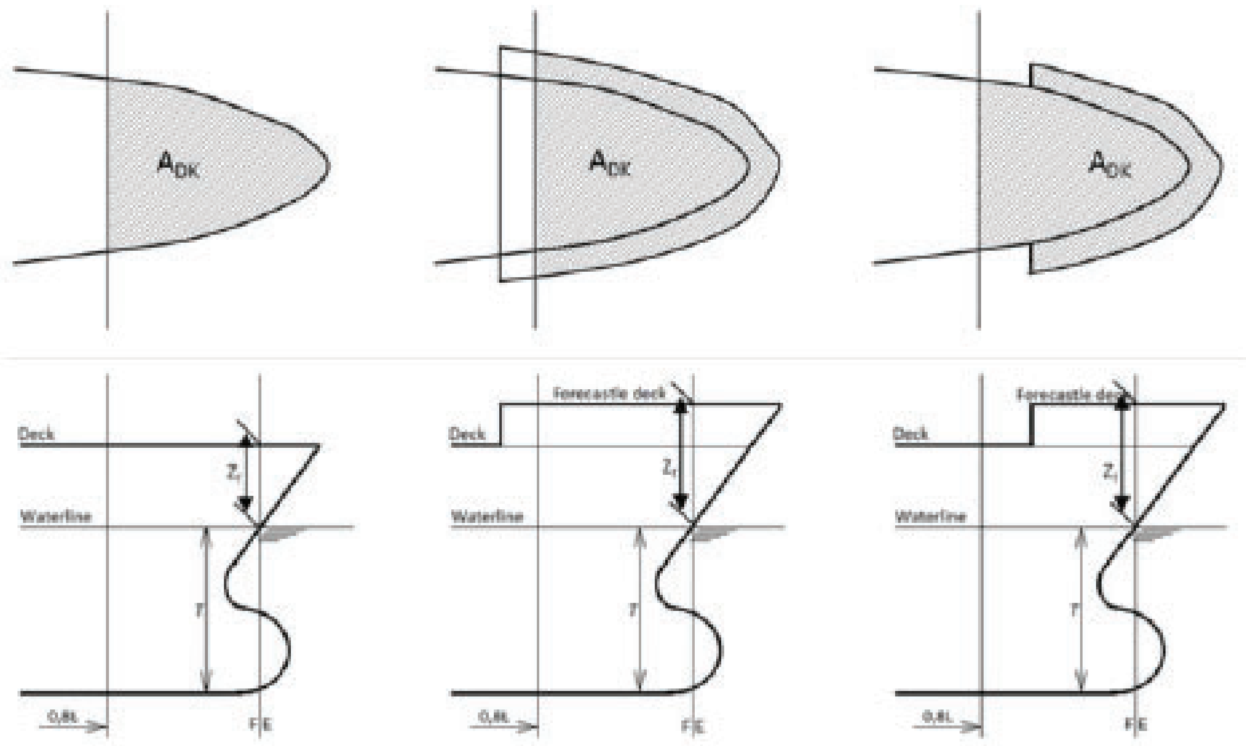


Figure 4 : Distribution of vertical wave bending moment M_{WV} along the ship length *(1/7/2016)*

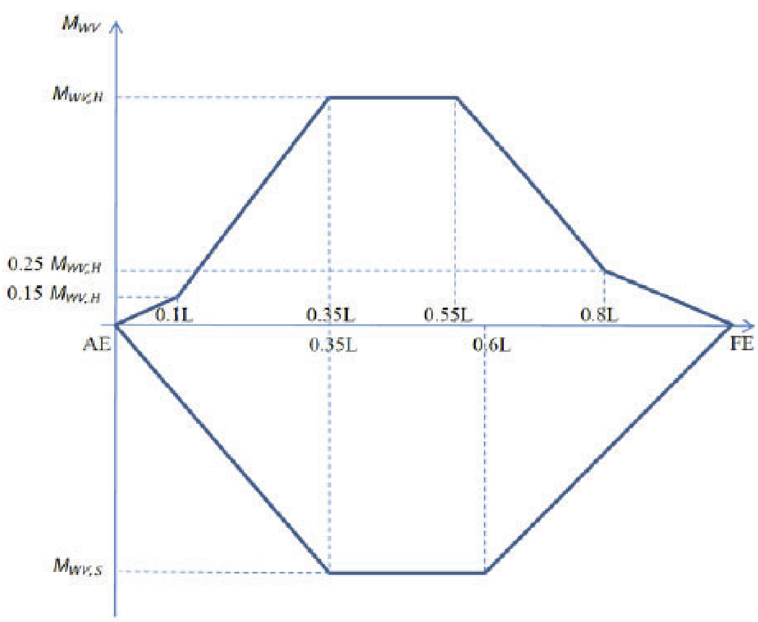
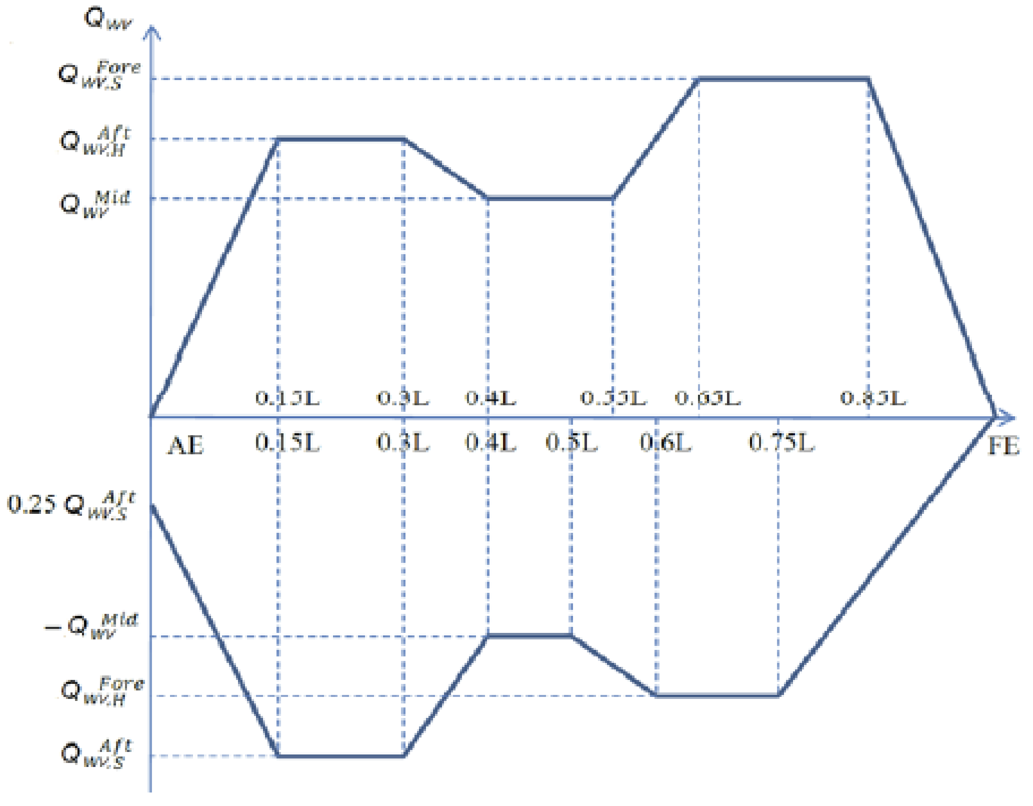


Figure 5 : Distribution of vertical wave shear Q_{WV} along the ship length *(1/7/2016)*



3.3 Hull girder load cases

3.3.1 Combination of still water and wave bending moments and shear forces *(1/7/2016)*

For the strength assessment, the maximum hogging and sagging load cases given in Tab 3 are to be checked. For each load case the still water condition at each section as defined in [3.1] is to be combined with the wave condition as defined in [3.2], refer also to Fig 6.

Table 3 : Combination of still water and wave bending moments and shear forces *(15/4/2019)*

Load case	Bending moment		Shear force	
	M_{SW}	M_{WV}	Q_{SW}	Q_{WV}
Hogging	M_{SWmax}	$M_{WV,H}$	Q_{SWmax} for $x \leq 0{,}5L$	Q_{wvmax} for $x \leq 0{,}5L$
			Q_{SWmin} for $x > 0{,}5L$	Q_{wvmin} for $x > 0{,}5L$
Sagging	M_{SWmin}	$M_{WV,S}$	Q_{SWmin} for $x \leq 0{,}5L$	Q_{wvmin} for $x \leq 0{,}5L$
			Q_{SWmax} for $x > 0{,}5L$	Q_{wvmax} for $x > 0{,}5L$

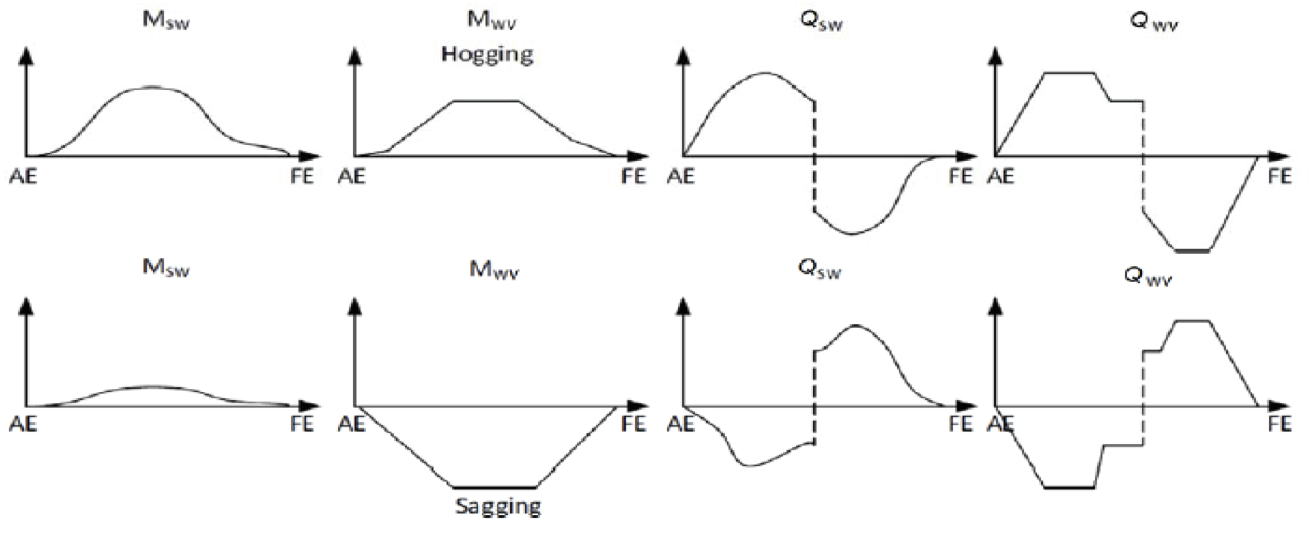
$M_{WV,H}$: Wave bending moment in hogging at the cross section under consideration, to be taken as the positive value of M_{WV} as defined in Fig 4

$M_{WV,S}$: Wave bending moment in sagging at the cross section under consideration, to be taken as the negative value of M_{WV} as defined in Fig 4

Q_{WVmax} : Maximum value of the wave shear force at the cross section under consideration, to be taken as the positive value of Q_{WV} as defined in Fig 5

Q_{WVmin} : Minimum value of the wave shear force at the cross section under consideration, to be taken as the negative value of Q_{WV} as defined in Fig 5

Figure 6 : Load combination to determine the maximum hogging and sagging load cases as given in Tab 3 *(1/7/2016)*



3.4 Hull girder stresses

3.4.1 Normal stresses *(15/4/2019)*

The normal stresses induced by vertical bending moments, in N/mm², are obtained at the load calculation point under consideration, for the “hogging” and “sagging” load cases defined in [3.3] as follows:

$$\sigma_1 = \frac{M_{SW} + M_{WV}}{I_{net}}(z - N)10^{-3}$$

where:

I_{net} : Net vertical hull girder moment of inertia at the cross section under consideration, to be determined using net scantlings as defined in [2.1], in m⁴

N : Distance from the baseline to the horizontal neutral axis, in m.

3.4.2 Shear stresses *(1/7/2016)*

The shear stresses τ_1, in N/mm², induced by vertical shear forces at the load calculation point under consideration are obtained through direct calculation analyses based on thin walled beam models, as specified in Pt B, Ch 6, Sec 1, [2.6], using the net scantlings as defined in [2.1].

The hull girder loads to be considered in these analyses are the vertical shear forces Q_{SW} and Q_{WV}, defined in [3.1] and [3.2] for the "hogging" and "sagging" load cases defined in [3.3].

4 Yielding checks

4.1 General

4.1.1 *(1/7/2016)*

Continuity of structure is to be maintained throughout the length of the ship. Where significant changes in structural arrangement occur adequate transitional structure is to be provided.

4.2 Moment of inertia

4.2.1 Stiffness criterion *(1/7/2016)*

The two load cases "hogging" and "sagging" as listed in [3.3] are to be checked.

The net moment of inertia, in m⁴, is not to be less than:.

$$I_{net} \geq 1,55L|M_{SW} + M_{WV}|10^{-7}$$

4.3 Checking criteria

4.3.1 General acceptance criteria *(1/7/2016)*

The yield strength assessment is to check, for each of the load cases "hogging" and "sagging" as defined in [3.3], that the equivalent hull girder stress σ_{EQ}, in N/mm², is less than the allowable stress σ_{ALL}, in N/mm², as follows:.

$$\sigma_{EQ} < \sigma_{ALL}$$

where:

$$\sigma_{EQ} = \sqrt{\sigma_x^2 + 3\tau^2}$$

$$\sigma_{ALL} = \frac{R_{eH}}{\gamma_1 \gamma_2}$$

γ_1 : Partial safety factor for material:

$$\gamma_1 = k\frac{R_{eH}}{235}$$

γ_2 : Partial safety factor for load combinations and permissible stress:

γ_2 : 1.24, for bending strength assessment according to [4.3.2]

γ_2 : 1.13, for shear strength assessment according to [4.3.3]

4.3.2 Bending strength assessment *(1/7/2016)*

The assessment of the bending stresses is to be carried out according to [4.3.1] at the following locations of the cross section:

- At bottom
- At deck
- At top of hatch coaming
- At any point were there is a change of steel yield strength.

The following combination of hull girder stress as defined in [3.4] is to be considered:

$\sigma_x = \sigma_1$

$\tau = 0$

4.3.3 Shear strength assessment *(1/7/2016)*

The assessment of the shear stresses is to be carried out according to [4.3.1] for all structural elements that contribute to the shear strength capability.

The following combination of hull girder stress as defined in [3.4] is to be considered.

$\sigma_x = 0$

$\tau = \tau_1$

5 Buckling check

5.1 General

5.1.1 Application *(1/7/2016)*

The requirements of this Article apply for the buckling check of plate panels and longitudinal stiffeners subjected to hull girder bending and shear stresses.

5.2 Checking criteria

5.2.1 *(1//7/2016)*

The acceptance criterion for the buckling assessment is defined as follows:

$\eta_{act} \leq 1$

where:

η_{act} : Maximum utilization factor as defined in [5.2.2].

5.2.2 Buckling utilization factor *(1/7/2016)*

The utilization factor η_{act} is defined as the inverse of the stress multiplication factor at failure γ_c (see Fig 7):

$$\eta_{act} = \frac{1}{\gamma_c}$$

Failure limit states for elementary plate panels are defined in [5.5] and [5.6]; failure limit states for overall stiffened panels are defined in [5.7]; failure limit states for longitudinal stiffeners are defined in [5.8].

Each failure limit state is defined by an equation, and γ_c is to be determined such that it satisfies the equation.

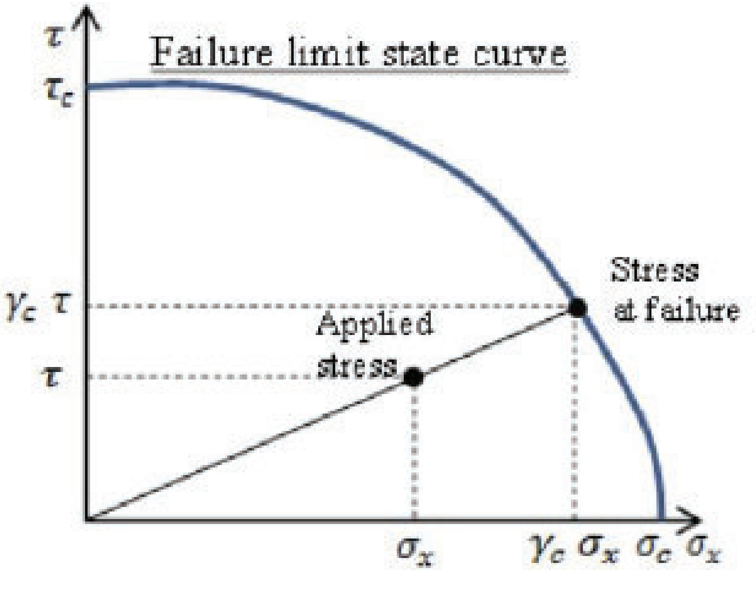
Fig 7 illustrates how the stress multiplication factor at failure γ_c of a structural member is determined for any combination of longitudinal and shear stress.

where:

σ_x , τ : Applied stress combination for buckling given in [5.3.1].

σ_c , τ_c : Critical buckling stresses.

Figure 7 : Example of failure limit state curve and stress multiplication factor at failure *(1/7/2016)*



5.3 Stress determination

5.3.1 Stress combinations for buckling assessment *(1/7/2016)*

The following two stress combinations are to be considered for each of the load cases "hogging" and "sagging" as defined in [3.3]. The stresses are to be derived at the load calculation points defined in [5.3.2].

a) Longitudinal stiffening arrangement

Stress combination 1 with:

$\sigma_x = \sigma_1$

$\sigma_y = 0$

$\tau = 0,7\ \tau_1$

Stress combination 2 with

$\sigma_x = 0,7\ \sigma_1$

$\sigma_y = 0$

$\tau = \tau_1$

b) Transverse stiffening arrangement

Stress combination 1 with:

$\sigma_x = 0$

$\sigma_y = \sigma_1$

$\tau = 0,7\ \tau_1$

Stress combination 2 with

$\sigma_x = 0$

$\sigma_y = 0,7\ \sigma_1$

$\tau = \tau_1$

where:

x axis : Local axis of a rectangular buckling panel parallel to its longer edge

y axis : Local axis of a rectangular buckling panel perpendicular to its longer edge

σ_x : Membrane stress applied in x direction, in N/mm^2

σ_y : Membrane stress applied in y direction, in N/mm^2

τ : Membrane shear stress applied in xy plane, in N/mm^2.

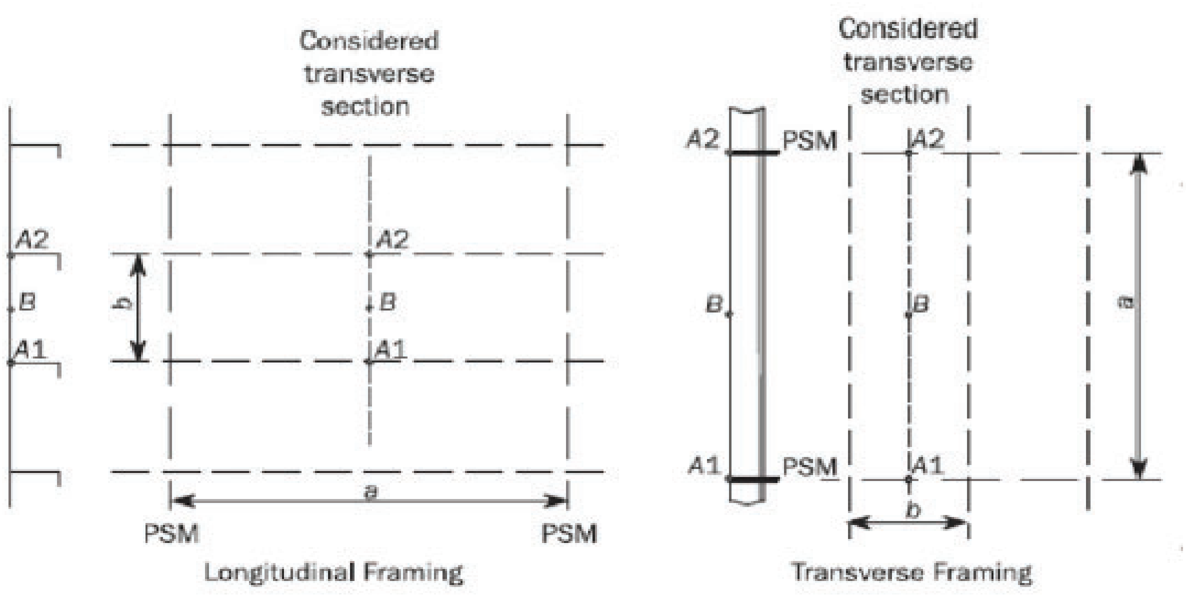
5.3.2 Load calculation points *(1/7/2016)*

The hull girder stresses for elementary plate panels (EPP) are to be calculated at the load calculation points defined in Tab 4.

Table 4 : Load calculation points (LCP) coordinates for plate buckling assessment *(1/7/2016)*

LCP coordinates	Hull girder bending stress		Hull girder shear stress
	Non horizontal plating	Horizontal plating	
x coordinate	Mid-length of the EPP		
y coordinate	Both upper and lower ends of the EPP (points A1 and A2 in Fig 8)	Outboard and inboard ends of the EPP (points A1 and A2 in Fig 8)	Mid-point of EPP (point B in Fig 8)
z coordinate	Corresponding to x and y values		

Figure 8 : LCP for plate buckling assessment, PSM stands for primary supporting members *(1/7/2016)*



The hull girder stresses for longitudinal stiffeners are to be calculated at the following load calculation point:

- at the mid length of the considered stiffener
- at the intersection point between the stiffener and its attached plate.

5.4 Elementary Plate Panel

5.4.1 Definition *(1/7/2016)*

An Elementary Plate Panel (EPP) is the unstiffened part of the plating between stiffeners and/or primary supporting members.

5.4.2 EPP with different thicknesses *(15/4/2019)*

a) Longitudinally stiffened EPP with different thicknesses

In longitudinal stiffening arrangement, when the plate thickness varies over the width, b, in mm, of a plate panel, the buckling capacity is calculated on an equivalent plate panel width, having a thickness equal to the smaller plate thickness, t_1. The width of this equivalent plate panel, b_{eq}, in mm, is defined by the following formula:

$b_{eq} = \ell_1 + \ell_2 (t_1 / t_2)^{1,5}$

where:

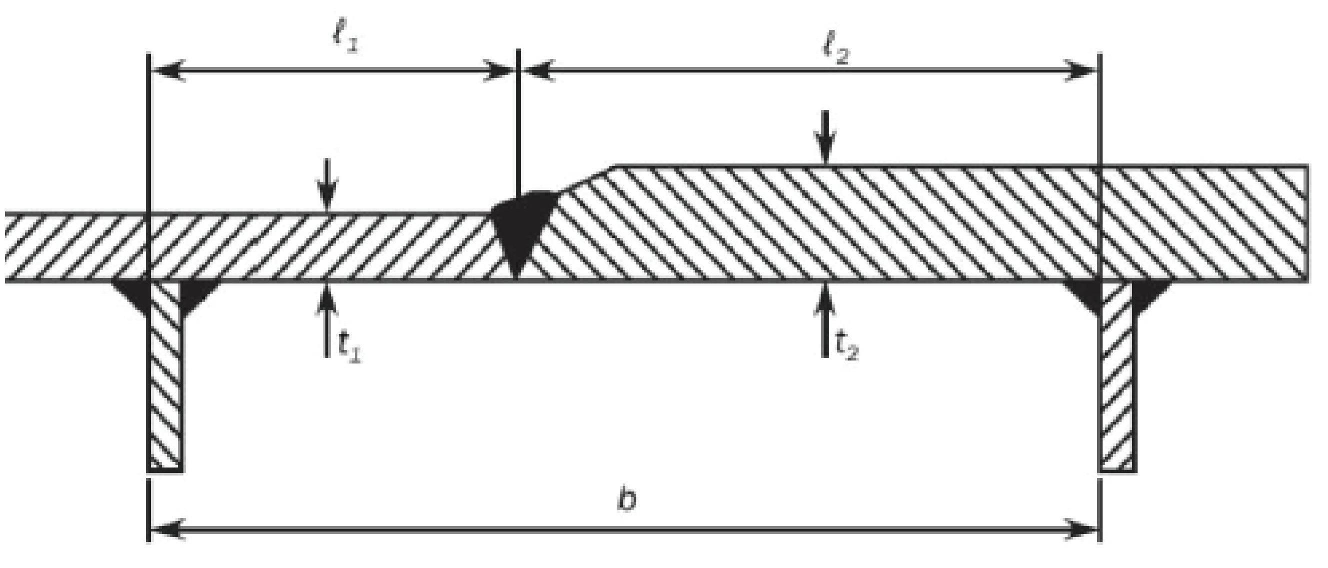
ℓ_1 : Width of the part of the plate panel with the smaller plate thickness, t_1 in mm (see Fig 9).

ℓ_2 : Width of the part of the plate panel with the greater plate thickness, t_2 in mm (see Fig 9).

b) Transversally stiffened EPP with different thickness

In transverse stiffening arrangement, when an EPP is made of different thicknesses, the buckling check of the plate and stiffeners is to be made for each thickness considered constant on the EPP.

Figure 9 : Plate thickness change over the width *(1/7/2016)*



5.5 Buckling capacity of plate panels

5.5.1 Plate limit state *(1/7/2016)*

The plate limit state is based on the following interaction formulae:

a) Longitudinal stiffening arrangement

$$\left(\frac{\gamma_c \sigma_x}{\sigma_{cx}}\right)^{2/\beta_p^{0,25}} + \left(\frac{\gamma_c |\tau|}{\tau_c}\right)^{2/\beta_p^{0,25}} = 1$$

b) Transverse stiffening arrangement

$$\left(\frac{\gamma_c \sigma_y}{\sigma_{cy}}\right)^{2/\beta_p^{0,25}} + \left(\frac{\gamma_c |\tau|}{\tau_c}\right)^{2/\beta_p^{0,25}} = 1$$

where:

σ_x , σ_y : Applied normal stress to the plate panel in N/mm², defined in [5.3], at load calculation points of the considered elementary plate panel.

τ : Applied shear stress to the plate panel in N/mm², defined in [5.3], at load calculation points of the considered elementary plate panel.

σ_{cx} : Ultimate buckling stress, in N/mm², in direction parallel to the longer edge of the buckling panel, defined in [5.5.3].

σ_{cy} : Ultimate buckling stress, in N/mm², in direction parallel to the shorter edge of the buckling panel, defined in [5.5.3].

τ_c : Ultimate buckling shear stress in N/mm², defined in [5.5.3].

β_p : Plate slenderness parameter to be obtained from the following formula:

$$\beta_p = \frac{b}{t_p}\sqrt{\frac{R_{eH\_p}}{E}}$$

5.5.2 Reference degree of slenderness *(1/7/2016)*

The reference degree of slenderness is to be obtained from the following formula:

$$\lambda = \sqrt{\frac{R_{eH\_p}}{K\sigma_E}}$$

where:

K : Buckling factor as defined in Tab 6 and Tab 7.

5.5.3 Ultimate buckiling stresses *(15/4/2019)*

The ultimate buckling stress of plate panels, in N/mm², is obtained from the following formula:

$$\sigma_{cx} = C_x R_{eH\_p}$$

$$\sigma_{cy} = C_y R_{eH\_p}$$

The ultimate buckling stresses subject to shear, in N/mm², is obtained from the following formula:

$$\tau_c = C_\tau \frac{R_{eH\_p}}{\sqrt{3}}$$

where:

C_x, C_y, C_τ: Reduction factor as defined in Tab 6 and Tab 7.

The boundary conditions for plates are to be considered as simply supported (see cases 1, 2 and 15 of Tab 6). If the boundary conditions differ significantly from simple support, a more appropriate boundary condition can be applied according to the different cases of Tab 6 subject to the agreement of the Society on a case-by-case basis.

5.5.4 Correction Factor F_{long} *(15/4/2019)*

The correction factor F_{long} depending on the edge stiffener types on the longer side of the buckling panel is defined in Tab 5. An average value of F_{long} is to be used for plate panels having different edge stiffeners. For stiffener types other than those mentioned in Tab 5, the value of c is to be considered by the Society on a case-by-case basis. In such a case, value of c higher than those mentioned in Tab 5 can be used, provided it is verified by buckling strength check of panel using non-linear FE analysis and deemed appropriate by the Society.

Table 5 : Correction factor F_{long} *(1/7/2016)*

Structural element types			F_{long}	C
Unstiffened Panel			1,0	N/A
Stiffened Panel	Stiffener not fixed at both ends		1,0	N/A
	Stiffener fixed at both ends	Flat bar **(1)**	$F_{long} = c + 1 \quad \text{for} \frac{t_w}{t_p} > 1$ $F_{long} = c\left(\frac{t_w}{t_p}\right)^3 + 1 \quad \text{for} \frac{t_w}{t_p} \le 1$	0,10
		Bulb profile		0,30
		Angle profile		0,40
		T profile		0,30
		Girder of high rigidity (e.g. bottom transverse)	1,4	N/A
(1) t_W is the net web thickness, in mm, without the correction defined in [5.8.3]				

The meaning of the symbols in Tab 6 is as follows:

α : Aspect ratio of the plate panel, to be taken as: $\alpha = a/b$

β : Coefficient to be taken as:

$$\beta = \frac{1-\psi}{\alpha}$$

ω : Coefficient taken as:

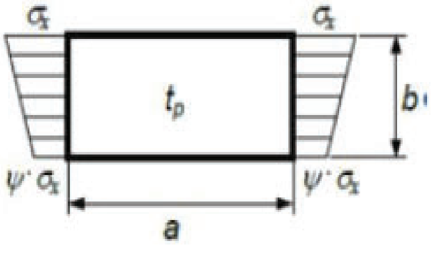
$\omega = \min(3;\alpha)$

ψ : Edge stress ratio to be taken as: $\psi = \sigma_2/\sigma_1$

σ_1 : Maximum stress, in N/mm²

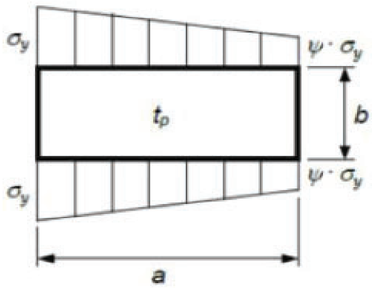
σ_2 : Minimum stress, in N/mm²

Table 6 : Buckling factor and reduction factor for plane plate panels *(15/4/2019)*

Case	Stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor C
1 	$1 \geq \psi \geq 0$		$K_x = F_{long}\dfrac{8,4}{\psi + 1,1}$	$C_x = 1$ for $\lambda \leq \lambda_c$ $C_x = c\left(\dfrac{1}{\lambda} - \dfrac{0,22}{\lambda^2}\right)$ for $\lambda > \lambda_c$ where: $c = (1,25 - 0,12\psi) \leq 1,25$ $\lambda_c = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0,88}{c}}\right)$
	$0 > \psi > -1$		$K_x = F_{long}[7,63 - \psi(6,26 - 10\psi)]$	
	$\psi \leq -1$		$K_x = F_{long}[5,975(1 - \psi)^2]$	

Edge boundary conditions:
- - - - - - - - Plate edge free
——————— Plate edge simply supported
——————— Plate edge clamped

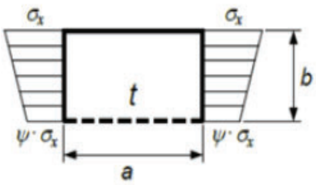
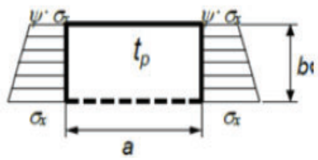
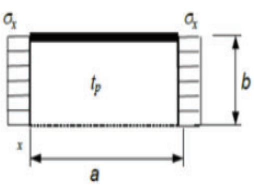
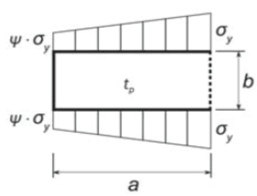
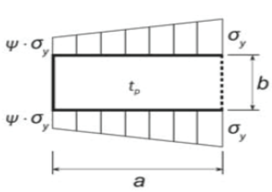
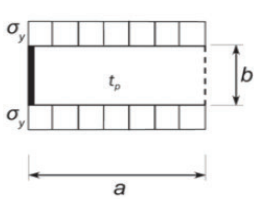
(1) Cases listed are general cases. Each stress component (σ_x, σ_y) is to be understood in local coordinates.

<table>
<tr><th>Case</th><th>Stress ratio ψ</th><th>Aspect ratio α</th><th>Buckling factor K</th><th>Reduction factor C</th></tr>
<tr><td rowspan="7">2

</td><td rowspan="3">$1 \geq \psi \geq 0$</td><td colspan="2">$$K_y = \frac{2\left(1 + \frac{1}{\alpha^2}\right)^2}{1 + \psi + \frac{(1-\psi)}{100}\left(\frac{2,4}{\alpha^2} + 6,9f_1\right)}$$</td><td rowspan="7">$$C_y = c\left(\frac{1}{\lambda} - \frac{R + F^2(H-R)}{\lambda^2}\right)$$
where:
$c = (1,25 - 0,12\psi) \leq 1,25$

$R = \lambda(1 - \lambda/c)$ for $\lambda < \lambda_c$
$R = 0,22$ for $\lambda \geq \lambda_c$

$$\lambda_c = 0,5c\left(1 + \sqrt{1 - \frac{0,88}{c}}\right)$$
$$F = \left(1 - \left(\frac{K}{0,91} - 1\right)/\lambda_p^2\right)c_1 \geq 0$$
$\lambda_p^2 = \lambda^2 - 0,5$ for $1 \leq \lambda_p^2 \leq 3$
$c_1 = (1 - 1/\alpha) \geq 0$
$$H = \lambda - \frac{2\lambda}{c(T + \sqrt{T^2 - 4})} \geq R$$
$$T = \lambda + \frac{14}{15\lambda} + \frac{1}{3}$$</td></tr>
<tr><td>$\alpha \leq 6$</td><td>$f_1 = (1 - \psi)(\alpha - 1)$</td></tr>
<tr><td>$\alpha > 6$</td><td>$$f_1 = 0,6\left(1 - \frac{6\psi}{\alpha}\right)\left(\alpha + \frac{14}{\alpha}\right)$$
but not greater than
$14,5 - (0,35 / \alpha^2)$</td></tr>
<tr><td rowspan="4">$0 > \psi \geq 1 - 4\alpha/3$</td><td colspan="2">$$K_y = \frac{200(1 + \beta^2)^2}{(1 - f_3)(100 + 2,4\beta^2 + 6,9f_1 + 23f_2)}$$</td></tr>
<tr><td>$\alpha > 6(1-\psi)$</td><td>$$f_1 = 0,6\left(\frac{1}{\beta} + 14\beta\right)$$
but not greater than $14,5 - 0,35\beta^2$
$f_2 = f_3 = 0$</td></tr>
<tr><td>$3(1-\psi) \leq \alpha \leq 6(1-\psi)$</td><td>$f_1 = 1/\beta - 1$
$f_2 = f_3 = 0$</td></tr>
<tr><td>$1,5(1-\psi) \leq \alpha < 3(1-\psi)$</td><td>$$f_1 = \frac{1}{\beta} - (2 - \omega\beta)^4 - 9(\omega\beta - 1)\left(\frac{2}{3} - \beta\right)$$
$f_2 = f_3 = 0$</td></tr>
<tr><td colspan="5">Edge boundary conditions:
- - - - - - - - Plate edge free
———— Plate edge simply supported
———— Plate edge clamped</td></tr>
<tr><td colspan="5">(1) Cases listed are general cases. Each stress component (σ_x, σ_y) is to be understood in local coordinates.</td></tr>
</table>

Case	Stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor C
		$1-\psi \le \alpha < 1,5(1-\psi)$	For $\alpha > 1,5$: $f_1 = 2\left(\frac{1}{\beta} - 16\left(1 - \frac{\omega}{3}\right)^4\right)\left(\frac{1}{\beta} - 1\right)$ $f_2 = 3\beta - 2$ $f_3 = 0$ For $\alpha \le 1,5$: $f_1 = 2\left(\frac{1,5}{1-\psi} - 1\right)\left(\frac{1}{\beta} - 1\right)$ $f_2 = \frac{\psi(1 - 16f_4^2)}{1-\alpha}$ $f_3 = 0$ $f_4 = (1,5 - Min(1,5;\alpha))^2$	
		$0,75(1-\psi) \le \alpha < 1-\psi$	$f_1 = 0$ $f_2 = 1 + 2,31(\beta - 1) - 48\left(\frac{4}{3} - \beta\right)f_4^2$ $f_3 = 3f_4(\beta - 1)\left(\frac{f_4}{1,81} - \frac{\alpha - 1}{1,31}\right)$ $f_4 = (1,5 - Min(1,5;\alpha))^2$	
	$\psi < 1-4\alpha/3$	$K_y = 5,972\frac{\beta^2}{1-f_3}$ where: $f_3 = f_5\left(\frac{f_5}{1,81} + \frac{1+3\psi}{5,24}\right)$ $f_5 = \frac{9}{16}(1 + max(-1;\psi))^2$		
Edge boundary conditions: - - - - - - - - Plate edge free ———— Plate edge simply supported ———— Plate edge clamped				
(1) Cases listed are general cases. Each stress component (σ_x, σ_y) is to be understood in local coordinates.				

Case	Stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor C
3 	$1 \geq \psi \geq 0$		$K_x = \dfrac{4(0,425 + 1/\alpha^2)}{3\psi + 1}$	$C_x = 1$ for $\lambda \leq 0,7$ $C_x = \dfrac{1}{\lambda^2 + 0,51}$ for $\lambda > 0,7$
	$0 > \psi \geq -1$		$K_x = 4(0,425 + 1/\alpha^2)(1 + \psi) - 5\psi(1 - 3,42\psi)$	
4 	$1 \geq \psi \geq -1$		$K_x = (0,425 + 1/\alpha^2)\dfrac{(3 - \psi)}{2}$	
5 		$\alpha \geq 1,64$	$K_x = 1,28$	
		$\alpha < 1,64$	$K_x = (1/\alpha^2) + 0,56 + 0,13\alpha^2$	
6 	$1 \geq \psi \geq 0$		$K_y = \dfrac{4(0,425 + \alpha^2)}{(3\psi + 1)\alpha^2}$	$C_y = 1$ for $\lambda \leq 0,7$ $C_y = \dfrac{1}{\lambda^2 + 0,51}$ for $\lambda > 0,7$
	$0 > \psi \geq -1$		$K_y = 4(0,425 + \alpha^2)(1 + \psi)\dfrac{1}{\alpha^2} - 5\psi(1 - 3,42\psi)\dfrac{1}{\alpha^2}$	
7 	$1 \geq \psi \geq -1$		$K_y = (0,425 + \alpha^2)\dfrac{(3 - \psi)}{2\alpha^2}$	
8 	-		$K_y = 1 + \dfrac{0,56}{\alpha^2} + \dfrac{0,13}{\alpha^4}$	

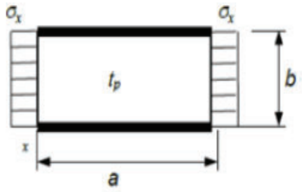
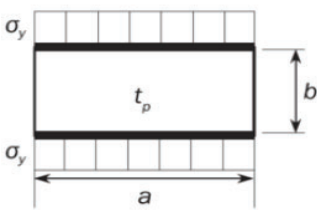
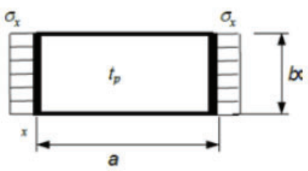
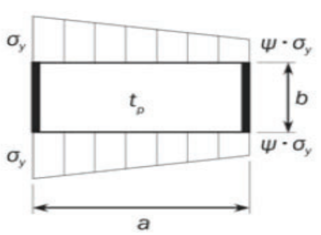
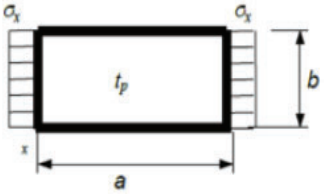
Edge boundary conditions:

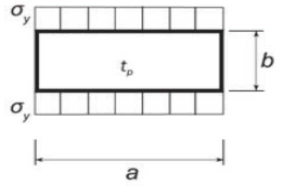
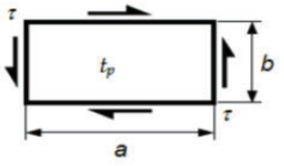
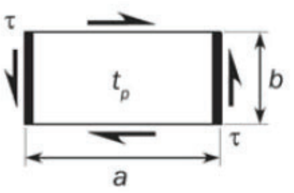
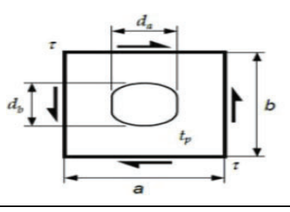
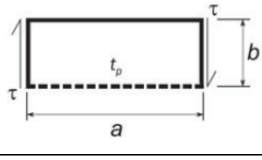
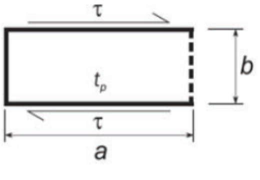
- - - - - - - - Plate edge free

———— Plate edge simply supported

———— Plate edge clamped

(1) Cases listed are general cases. Each stress component (σ_x, σ_y) is to be understood in local coordinates.

Case	Stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor C
9 	-		$K_x = 6,97$	$C_x = 1$ for $\lambda \le 0,83$ $C_x = 1,13\left[\frac{1}{\lambda} - \frac{0,22}{\lambda^2}\right]$ for $\lambda > 0,83$
10 	-		$K_y = 4 + \frac{2,07}{\alpha^2} + \frac{0,67}{\alpha^4}$	
11 	-	$\alpha \ge 4$	$K_x = 4$	
		$\alpha < 4$	$K_x = 4 + 2,74\left(\frac{4-\alpha}{3}\right)^4$	
12 	-		$K_y = K_y$ determined as per case 2	$C_y = C_{y2}$ for $\alpha < 2$ $C_y = \left(1,06 + \frac{1}{10\alpha}\right)C_{y2}$ for $\alpha \ge 2$ where: $C_{y2} = C_y$ determined as per case 2
13 	-	$\alpha \ge 4$	$K_x = 6,97$	$C_x = 1$ for $\lambda \le 0,83$ $C_x = 1,13\left[\frac{1}{\lambda} - \frac{0,22}{\lambda^2}\right]$ for $\lambda > 0,83$
		$\alpha < 4$	$K_x = 6,97 + 3,1\left(\frac{4-\alpha}{3}\right)^4$	
Edge boundary conditions: - - - - - - - - Plate edge free ———— Plate edge simply supported ———— Plate edge clamped				
(1) Cases listed are general cases. Each stress component (σ_x, σ_y) is to be understood in local coordinates.				

Case	Stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor C
14 	-		$K_y = \frac{6,97}{\alpha^2} + \frac{3,1}{\alpha^2}\left(\frac{4-(1/\alpha)}{3}\right)^4$	$C_y = 1$ for $\lambda \le 0,83$ $C_y = 1,13\left[\frac{1}{\lambda} - \frac{0,22}{\lambda^2}\right]$ for $\lambda > 0,83$
15 	-		$K_\tau = \sqrt{3}\left[5,34 + \frac{4}{\alpha^2}\right]$	
16 	-		$K_\tau = \sqrt{3}\left[5,34 + Max\left(\frac{4}{\alpha^2};\frac{7,15}{\alpha^{2,5}}\right)\right]$	$C_\tau = 1$ for $\lambda \le 0,84$ $C_\tau = \frac{0,84}{\lambda}$ for $\lambda > 0,84$
17 	-		K = K'r K' = K according to case 15 r = opening reduction factor taken as $r = (1 - d_a/a)(1 - d_b/b)$ with $d_a/a \le 0,7$ and $d_b/b \le 0,7$	
18 	-		$K_\tau = 3^{0,5}(0,6 + 4/\alpha^2)$	$C_\tau = 1$ for $\lambda \le 0,84$ $C_\tau = \frac{0,84}{\lambda}$ for $\lambda > 0,84$
19 	-		$K_t = 8$	

Edge boundary conditions:
- - - - - - - - Plate edge free
——————— Plate edge simply supported
——————— Plate edge clamped

(1) Cases listed are general cases. Each stress component (σ_x, σ_y) is to be understood in local coordinates.

5.6 Buckling capacity of curved plate panels

5.6.1 Curved plate limit state *(15/4/2019)*

This requirement for curved plate limit state is applicable if $R/tp \leq 2500$. Otherwise, the requirement for plate limit state given in [5.5.1] is applicable.

The curved plate limit state is based on the following interaction formula:

$$\left(\frac{\gamma_c\sigma_{ax}}{C_{ax}R_{eH\_P}}\right)^{1,25}+\left(\frac{\gamma_c\tau\sqrt{3}}{C_\tau R_{eH\_P}}\right)^2=1$$

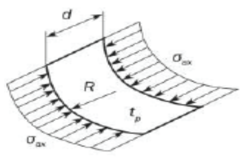
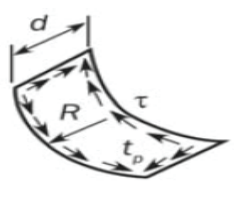
where:

σ_{ax} : Applied axial stress to the cylinder corresponding to the curved plate panel, in N/mm². In case of tensile axial stresses, $\sigma_{ax}=0$.

C_{ax} , C_τ : Buckling reduction factor of the curved plate panel, as defined in Tab 7.

The stress multiplier factor γ_c of the curved plate panel needs not be taken less than the stress multiplier factor γ_c for the expanded plane panel according to [5.5.1].

Table 7 : Buckling factor and reduction factor for curved plate panel with $R/t_p \leq 2500$ *(15/4/2019)*

Case	Aspect ratio	Buckling factor K	Reduction factor C
1 	$\frac{d}{R}\leq 0,5\sqrt{\frac{R}{t_p}}$	$K=1+\frac{2}{3}\frac{d^2}{Rt_p}$	For general application: $C_{ax}=1$ for $\lambda\leq 0,25$ $C_{ax}=1,233-0,933\lambda$ for $0,25<\lambda\leq 1$ $C_{ax}=0,3/\lambda^3$ for $1<\lambda\leq 1,5$ $C_{ax}=0,2/\lambda^2$ for $\lambda>1,5$ For curved single fields, e.g. bilge strake, which are bounded by plane panels: $C_{ax}=0,65/\lambda^2\leq 1,0$
	$\frac{d}{R}>0,5\sqrt{\frac{R}{t_p}}$	$K=0,267\frac{d^2}{Rt_p}\left(3-\frac{d}{R}\sqrt{\frac{t_p}{R}}\right)\geq 0,4\frac{d^2}{Rt_p}$	
2 	$\frac{d}{R}\leq 8,7\sqrt{\frac{R}{t_p}}$	$K=\sqrt{3}\sqrt{28,3+\frac{0,67d^3}{R^{1,5}t_p^{1,5}}}$	$C_\tau=1$ for $\lambda\leq 0,4$ $C_\tau=1,274-0,686\lambda$ for $0,4<\lambda\leq 1,2$ $C_\tau=0,65/\lambda^2$ for $\lambda>1,2$
	$\frac{d}{R}>8,7\sqrt{\frac{R}{t_p}}$	$K=\sqrt{3}\frac{0,28d^2}{R\sqrt{Rt_p}}$	
Explanations for boundary of overall stiffened plate ———— Plate edge simply supported			

5.7 Buckling capacity of overall stiffened plate

5.7.1 *(1/7/2016)*

The elastic stiffened panel limit state is based on the following interaction formula:

$$\frac{P_z}{c_f}=1$$

where P_z and c_f are defined in [5.8.4].

5.8 Buckling capacity of longitudinal stiffeners

5.8.1 Stiffeners limit states *(1/7/2016)*

The buckling capacity of longitudinal stiffeners is to be checked for the following limit states:

- Stiffener induced failure (SI)
- Associated plate induced failure (PI)

5.8.2 Lateral pressure *(1/7/2016)*

The lateral pressure is to be considered as constant in the buckling strength assessment of longitudinal stiffeners.

5.8.3 Stiffener idealization *(15/4/2019)*

a) Effective length of the stiffener ℓ_{eff}

The effective length of the stiffener ℓ_{eff}, in mm, is to be taken equal to:

$$\ell_{eff}=\frac{\ell}{\sqrt{3}}$$ for stiffener fixed at both ends

$\ell_{eff}=0,75\ell$, for stiffener simply supported at one end and fixed at the other

$\ell_{eff}=\ell$ for stiffener simply supported at both ends

b) Effective width of the attached plating b_{eff1}

The effective width of the attached plating of a stiffener b_{eff1}, in mm, without the shear lag effect is to be taken equal to:

$$b_{eff1} = \frac{C_{x1}b_1 + C_{x2}b_2}{2}$$

where:

C_{x1}, C_{x2} : Reduction factor defined in Tab 6 calculated for the EPP1 and EPP2 on each side of the considered stiffener according to case 1

b_1, b_2 : Width of the plate panel on each side of the considered stiffener, in mm.

c) Effective width of attached plating of stiffeners, b_{eff}, in mm, is to be taken as:

$$b_{eff} = \min(b_{eff1}, \chi_s s)$$

where:

χ_s : Effective width coefficient to be taken as:

$$\chi_s = \min\left[\frac{1,12}{1 + \frac{1,75}{\left(\frac{\ell_{eff}}{s}\right)^{1,6}}};1\right] \qquad \text{for} \frac{\ell_{eff}}{s} \geq 1$$

$$\chi_s = 0,407\frac{\ell_{eff}}{s} \qquad \text{for } \frac{\ell_{eff}}{s} < 1$$

d) Net thickness of attached plating t_p

The net thickness of plate t_p, in mm, is to be taken as the mean thickness of the two attached plating panels.

e) For accounting the decrease of stiffness due to local lateral deformation, the effective web thickness of flat bar stiffener, in mm, is to be used for the calculation of the net sectional area, A_s, the net section modulus, Z, and the moment of inertia, I, of the stiffener and is taken as:

$$t_{w\_red} = t_w\left[1 - \frac{2\pi^2}{3}\left(\frac{h_w}{s}\right)^2\left(1 - \frac{b_{eff1}}{s}\right)\right]$$

f) Net section modulus Z of a stiffener

The net section modulus Z of a stiffener, in cm³, including effective width of plating b_{eff} is to be taken equal to:

- the section modulus calculated at the top of stiffener flange for stiffener induced failure (SI).
- the section modulus calculated at the attached plating for plate induced failure (PI).

g) Net moment of inertia I of a stiffener

The net moment of inertia I, in cm⁴, of a stiffener including effective width of attached plating b_{eff} is to comply with the following requirement:

$$I \geq \frac{st_p^3}{12 \cdot 10^4}$$

h) Idealisation of bulb profile

A bulb section may be taken as equivalent to an angle profile as specified in Pt B, Ch 4, Sec 3, [3.1.2].

5.8.4 Ultimate buckling capacity *(15/4/2019)*

When $\sigma_a + \sigma_b + \sigma_w > 0$, the ultimate buckling capacity for stiffeners is to be checked according to the following interaction formula:

$$\frac{\gamma_c\sigma_a + \sigma_b + \sigma_w}{R_{eH}} = 1$$

where:

σ_a : Nominal axial stress, in N/mm², at mid-span of the stiffener acting on the stiffener with its attached plating, to be obtained from the following formula:

$$\sigma_a = \sigma_x\frac{st_p + A_s}{b_{eff1}t_p + A_s}$$

σ_x : Nominal axial stress, in N/mm², acting on the stiffener with its attached plating, calculated according to [5.3.1] at load calculation point of the stiffener

A_s : Net sectional area, in mm², of the considered stiffener

R_{eH} : Specified minimum yield stress of the material, in N/mm²:

- $R_{eH} = R_{eH\_S}$ for stiffener induced failure (SI)
- $R_{eH} = R_{eH\_P}$ for plate induced failure (PI)

σ_b : Bending stress in the stiffener, in N/mm², to be obtained from the following formula:

$$\sigma_b = \frac{M_0 + M_1}{Z}10^{-3}$$

M_1 : Bending moment, in Nmm, due to the lateral load P:

$$M_1 = C_i\frac{|P|s\ell^2}{24}10^{-3}$$

for continuous stiffener

$$M_1 = C_i\frac{|P|s\ell^2}{8}10^{-3}$$

for sniped stiffener

P : Lateral load, in kN/m², to be taken equal to the static pressure at the load calculation point of the stiffener

C_i : Pressure coefficient:

$C_i = C_{SI}$ for stiffener induced failure (SI)

$C_i = C_{PI}$ for plate induced failure (PI)

C_{PI} : Plate induced failure pressure coefficient:

C_{PI} = 1 if the lateral pressure is applied on the side opposite to the stiffener.

C_{PI} = -1 if the lateral pressure is applied on the same side as the stiffener.

C_{SI} : Stiffener induced failure pressure coefficient:

C_{SI} = -1 if the lateral pressure is applied on the side opposite to the stiffener.

C_{SI} = 1 if the lateral pressure is applied on the same side as the stiffener.

M_0 : Bending moment, in Nmm, due to the lateral deformation w of stiffener:

$$M_0 = F_E\left(\frac{P_z w}{c_f - P_z}\right)$$

with

$$(c_f - P_z) > 0$$

F_E : Ideal elastic buckling force of the stiffener, in N, to be obtained from the following formula:

$$F_E = \left(\frac{\pi}{\ell}\right)^2 EI\ 10^4$$

P_z : Nominal lateral load, in N/mm², acting on the stiffener due to stresses σ_x and τ, in the attached plating in way of the stiffener mid span:

$$P_z = \frac{t_p}{s}\left(\sigma_{x\ell}\left(\frac{\pi s}{\ell}\right)^2 + \sqrt{2}\tau_1\right)$$

$$\sigma_{x\ell} = \gamma_c \sigma_x\left(1 + \frac{A_s}{s t_p}\right)$$

but not less than 0

$$\tau_1 = (\gamma_c|\tau|) - t_p\sqrt{R_{eH\_P}E\left(\frac{m_1}{\alpha^2} + \frac{m_2}{s^2}\right)}$$

but not less than 0

m_1, m_2 : Coefficients taken equal to:

- m_1 = 1,47, m_2 = 0,49 for $\alpha \geq 2$
- m_1 = 1,96, m_2 = 0,37 for $\alpha < 2$

w : Deformation of stiffener, in mm, taken equal to:

$w = w_0 + w_1$

w_0 : Assumed imperfection, in mm, taken equal to:

- $w_0 = \ell \cdot 10^{-3}$ in general
- $w_0 = -w_{na}$ for stiffeners sniped at both ends, considering stiffener induced failure (SI)
- $w_0 = w_{na}$ for stiffeners sniped at both ends, considering plate induced failure (PI)

w_{na} : Distance, in mm, from the mid-point of attached plating to the neutral axis of the stiffener calculated with the effective width of the attached plating b_{eff}.

w_1 : Deformation of stiffener at midpoint of stiffener span due to lateral load P, in mm. In case of uniformly distributed load, w_1 is to be taken as:

- in general

$$w_1 = C_i\frac{|P| s \ell^4}{384EI}10^{-7}$$

- for stiffeners sniped at both ends

$$w_1 = C_i\frac{5|P| s \ell^4}{384EI}10^{-7}$$

c_f : Elastic support provided by the stiffener, in N/mm², to be taken equal to:

$$c_f = F_E\left(\frac{\pi}{\ell}\right)^2(1 + c_p)$$

c_p : Coefficient to be taken equal to:

$$c_p = \frac{1}{1 + \frac{0,91}{c_{xa}}\left(\frac{12 \cdot I \cdot 10^4}{s t_p^3} - 1\right)}$$

c_{xa} : Coefficient to be taken equal as:

$$c_{xa} = \left(\frac{\ell}{2s} + \frac{2s}{\ell}\right)^2 \text{for } \ell \geq 2s$$

$$c_{xa} = \left(1 + \left(\frac{\ell}{2s}\right)^2\right)^2 \text{for } \ell < 2s$$

σ_w : Stress due to torsional deformation, in N/mm², to be taken equal to:

- for stiffener induced failure (SI)

$$\sigma_w = E y_w\left(\frac{t_f}{2} + h_w\right)\Phi_0\left(\frac{\pi}{\ell}\right)^2\left(\frac{1}{1 - \frac{0,4R_{eH\_S}}{\sigma_{ET}}} - 1\right)$$

- for plate induced failure (PI)

$$\sigma_w = 0$$

y_w : Distance, in mm, from centroid of stiffener cross-section to the free edge of stiffener flange, to be taken as:

- for flat bar

$$y_w = \frac{t_w}{2}$$

- for angle and bulb profiles

$$y_w = b_f - \frac{h_w t_w^2 + t_f b_f^2}{2A_s}$$

- for Tee profile

$$y_w = \frac{b_f}{2}$$

Φ_0 : Coefficient to be taken as:

$$\Phi_0 = \frac{\ell}{h_w} 10^{-3}$$

σ_{ET} : Reference stress for torsional buckling, in N/mm²:

$$\sigma_{ET} = \frac{E}{I_p}\left(\frac{\varepsilon \pi^2 I_\omega}{\ell^2} 10^2 + 0,385 I_T\right)$$

I_p : Net polar moment of inertia of the stiffener about point C as shown in Fig 10, as defined in Tab 8, in cm⁴

I_T : Net St. Venant's moment of inertia of the stiffener, as defined in Tab 8, in cm⁴

I_ω : Net sectional moment of inertia of the stiffener about point C as shown in Fig 10, as defined in Tab 8, in cm⁶

ε : Degree of fixation, to be taken equal to:

$$\varepsilon = 1 + \frac{\left(\frac{\ell}{\pi}\right)^2 10^{-3}}{\sqrt{I_\omega\left(\frac{0,75 s}{t_p^3} + \frac{e_f - 0,5 t_f}{t_w^3}\right)}}$$

Table 8 : Moments of inertia *(1/7/2016)*

	Flat bars	Bulb, angle and Tee profiles
I_P	$\frac{h_w^3 t_w}{3 \cdot 10^4}$	$\left(\frac{A_w(e_f - 0,5 t_f)^2}{3} + A_f e_f^2\right) \cdot 10^{-4}$
I_T	$\frac{h_w t_w^3}{3 \cdot 10^4} \cdot \left(1 - 0,63 \frac{t_w}{h_w}\right)$	$\frac{(e_f - 0,5 t_f) t_w^3}{3 \cdot 10^4}\left(1 - 0,63 \frac{t_w}{(e_f - 0,5 t_f)}\right) + \frac{t_f^3 b_f}{3 \cdot 10^4} \cdot \left(1 - 0,63 \frac{t_f}{b_f}\right)$
I_ω	$\frac{h_w^3 t_w^3}{36 \cdot 10^6}$	For bulb and angle profiles: $\left(\frac{A_f e_f^2 b_f^2}{12 \cdot 10^6}\right) \cdot \frac{A_f + 2,6 A_w}{A_f + A_w}$ For Tee profiles: $\left(\frac{b_f^3 t_f e_f^2}{12 \cdot 10^6}\right)$

Note 1:

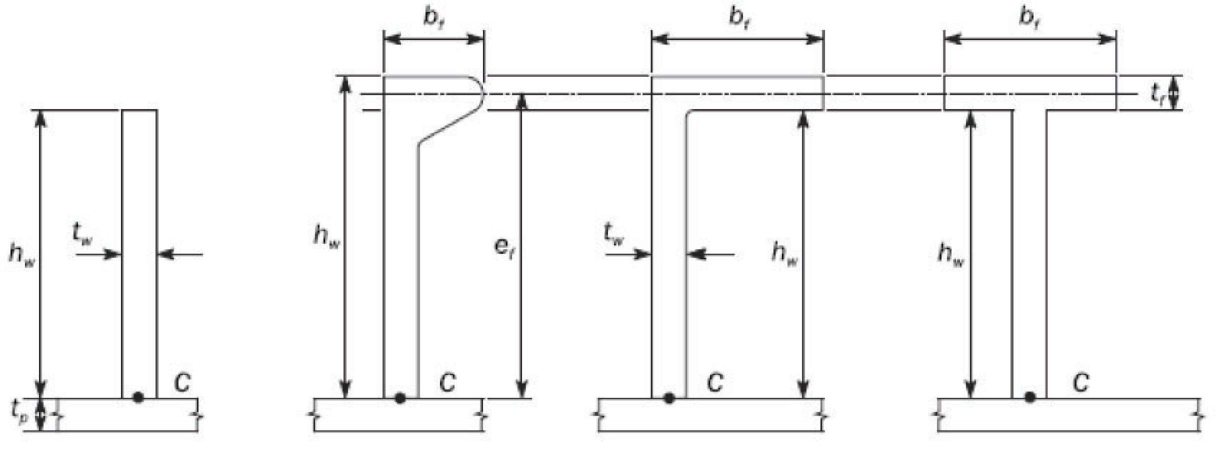
A_w : Net web area, in mm²

A_f : Net flange area, in mm²

e_f : Distance from attached plating to centre of flange, in mm, to be taken as:

- $e_f = h_w$ for flat bar profile
- $e_f = h_w - 0,5\ t_f$ for bulbe profile
- $e_f = h_w + 0,5\ t_f$ for angle and Tee profiles

Figure 10 : Stiffener cross section *(1/7/2016)*



6 Ultimate strength check

6.1 Hull girder ultimate bending moment

6.1.1 *(1/7/2016)*

The vertical hull girder bending moment, M in hogging and sagging conditions, to be considered in the ultimate strength check is to be taken as:

$$M = \gamma_{s1} M_{SW} + \gamma_{wS1} M_{WV}$$

where:

- M_{SW} : Permissible still water bending moment, in kNm defined in [3.3]
- M_{WV} : Vertical wave bending moment, in kNm, defined in [3.3]
- γ_{s1} : Partial safety factor for the still water bending moment, to be taken as:

  γ_{s1} = 1,0
- γ_{w1} : Partial safety factor for the vertical wave bending moment, to be taken as:

  γ_{w1} = 1,2

6.2 Hull girder ultimate bending capacity

6.2.1 General *(1//7/2016)*

The hull girder ultimate bending moment capacity, M_U is defined as the maximum bending moment capacity of the hull girder beyond which the hull structure collapses.

6.2.2 Determination of hull girder ultimate bending moment capacity *(1/7/2016)*

The ultimate bending moment capacities of a hull girder transverse section, in hogging and sagging conditions, are defined as the maximum values of the curve of bending moment M versus the curvature χ of the transverse section considered (M_{UH} for hogging condition and M_{US} for sagging condition, see Fig 11). The curvature χ is positive for hogging condition and negative for sagging condition.

The hull girder ultimate bending moment capacity M_U is to be calculated using the incremental-iterative method as given in Pt B, Ch 6, App 1, [2], using the net thickness approach described in [2.1] for the determination of the geometric properties (I_Y, h_w, t_w, b_f, t_f, A_s, t_p).

As an alternative, a non-linear finite element analysis as indicated in Pt B, Ch 6, App 1, [3] may be used.

6.3 Acceptance criteria

6.3.1 *(1/7/2016)*

The hull girder ultimate bending capacity at any hull transverse section is to satisfy the following criteria:

$$\frac{M_U}{\gamma_M \gamma_{DB}} \geq M$$

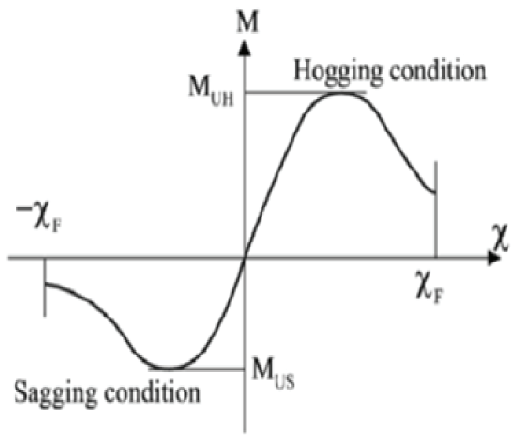
where:

- M : Vertical bending moment, in kNm, to be obtained as specified in [6.1].
- M_U : Hull girder ultimate bending moment capacity, in kNm, to be obtained as specified in [6.2].
- γ_M : Partial safety factor for the hull girder ultimate bending capacity, covering material, geometric and strength prediction uncertainties, to be taken as:

  γ_M = 1,05
- γ_{DB} : Partial safety factor for the hull girder ultimate bending moment capacity, covering the effect of double bottom bending, to be taken as:
  - For hogging condition: γ_{DB} = 1.15
  - For sagging condition: γ_{DB} = 1,0

For cross sections where the double bottom breadth of the inner bottom is less than that at amidships or where the double bottom structure differs from that at amidships (e.g. engine room sections), a reduction of factor γ_{DB} for hogging condition may be considered by the Society on a case by case basis.

Figure 11 : Bending moment M versus curvature χ *(1/7/2016)*



6.4 Additional requirements for large container ships

6.4.1 General *(1/7/2017)*

The requirements of this section are applicable to ships with service notation container ship with a breadth B greater than 32.26 m.

6.4.2 Whipping *(1/7/2017)*

Hull girder ultimate strength assessment is to take into consideration the whipping contribution to the vertical bending moment according to the "Tasneef Guide for whipping and springing assessment".

Part E
Service Notations

Chapter 3
LIVESTOCK CARRIERS

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 Ships complying with the requirements of this Chapter are eligible for the assignment of the service notation **livestock carrier**, as defined in Pt A, Ch 1, Sec 2, [4.2.7].

1.1.2 Ships dealt with in this Chapter are to comply with the requirements stipulated in Part A, Part B, Part C and Part D, as applicable and with the requirements of this Chapter, which are specific to livestock carriers.

1.2 Summary table

1.2.1 Tab 1 indicates, for easy reference, the Sections of this Chapter dealing with requirements applicable to livestock carriers.

Table 1 *(1/1/2007)*

Main subject	Reference
Ship arrangement	**(1)**
Hull and stability	Sec 2
Machinery and systems serving livestock spaces	Sec 3
Electrical installations	**(1)**
Automation	**(1)**
Fire protection, detection and extinction	**(1)**

(1) No specific requirements for livestock carriers are given in this Chapter.

SECTION 2 HULL AND STABILITY

1 General arrangement design

1.1 Livestock arrangement

1.1.1 The livestock are to be kept in pens. The dimensions of these pens are to be suitable for the livestock carried. In general, the breadth and the length of the pen may not be greater than 4,5 m and 9 m, respectively.

The livestock may not be carried on hatch covers unless the latter are effectively protected.

1.2 Arrangement of spaces dedicated to the carriage of livestock

1.2.1 General

The requirements of this item apply to the arrangement of the spaces dedicated to the carriage of livestock. When deemed necessary by the Society, such spaces may need to be adapted or complemented depending on the species of animals which are to be carried.

1.2.2 Protection of livestock

Arrangements for protecting the livestock from injury, avoidable suffering and exposure to weather, sea or hot parts are to be provided.

1.2.3 Livestock arrangement

Livestock may not be carried, or loaded for carriage, in any part of a ship where the livestock, livestock fittings, livestock equipment or carrying arrangements may:

- obstruct access to any accommodation space or working space necessary for the safe running of the ship, or the means of egress from any hold or underdeck space
- interfere with life-saving or fire-fighting appliances
- interfere with the tank sounding equipment or bilge pumping
- interfere with the operation of closing appliances
- interfere with the operation of freeing ports
- interfere with the lighting or ventilation of other parts of the ships
- interfere with the proper navigation of the ship.

1.3 Means of escape and access

1.3.1 General

In each space in which livestock is carried, not less than two means of escape for persons are to be fitted, widely separated and giving access to an open deck.

Access to livestock space for persons is to be safe. Where it is combined with a ramp used for moving livestock between decks, it is to be separated from the livestock ramp by protective fencing.

1.3.2 Closing arrangement

Pens, stalls and similar fittings are to be provided with a means of access for persons with secure closing arrangement whose structural strength is to be considered by the Society on a case-by-case basis.

1.3.3 Passageway width

If access between a ship side and a pen, stall or similar fitting is required for purposes of safe and proper operation of ship, a passageway not less than 550 mm wide is to be provided between the ship's rail or bulwark and the rails or receptacles of the pen, stall or fitting.

2 Corrosion additions

2.1

2.1.1 General *(1/7/2016)*

In lieu of the values specified in Pt B, Ch 4, Sec 2, [3], the corrosion addition relevant to dry bulk cargo holds intended to carry livestock only is to be taken equal to 0,5 mm.

3 Stability

3.1 Intact stability

3.1.1 General

The stability of the ship for the loading conditions reported in the trim and stability booklet is to be in compliance with the requirements of Pt B, Ch 3, Sec 2.

3.1.2 Additional requirements

Where national or international rules apply, the Society reserves the right to adopt the rules in force in the country in which the ship is registered or in which the ship trades.

4 Hull girder strength

4.1 Application

4.1.1 In general, the decks and platform decks above the strength deck used for the carriage of livestock may not be taken into account for the calculation of the section modulus.

5 Hull scantlings

5.1 Scantlings of plating, ordinary stiffeners and primary supporting members

5.1.1 Movable or collapsible structural elements above the strength deck

In general, the movable or collapsible structural elements above the strength deck used for the stocking and the distribution of livestock on decks or platform decks are not a part of ship classification.

Nevertheless, where the ship's safety may be compromised by lack of strength of these elements, they are to be checked according to the criteria in Part B, Chapter 7 or Part B, Chapter 8, as applicable. In this case, the scantlings of the barriers surrounding each pen are to take into account the loads applied by the livestock as a result of roll and pitch of the ship.

SECTION 3 MACHINERY AND SYSTEMS SERVING LIVESTOCK SPACES

1 General

1.1 Application

1.1.1 The provisions of this Section cover the systems installed on ships having the service notation **livestock carrier** and intended for:

- the supply of food, water and fresh air to the livestock
- the cleaning of the livestock spaces
- the draining of the sewage effluents produced by the livestock.

1.2 Documents to be submitted

1.2.1 The documents listed in Tab 1 are to be submitted for approval.

2 Design of the systems

2.1 General

2.1.1 The piping systems covered by this Section are to be designed, constructed and tested in accordance with the applicable provisions of Pt C, Ch 1, Sec 10.

2.2 Ventilation system

2.2.1 General

Mechanical ventilation is to be provided for the following spaces containing livestock:

- enclosed spaces
- partially closed spaces arranged with pens on more than one deck level and having a breadth greater than 20 m.

2.2.2 Capacity of the mechanical ventilation

The capacity of the mechanical ventilation is not to be less than:

- 20 air changes per hour of each enclosed space
- 15 air changes per hour of each partially closed space,

based on the gross volume of the space, deduced, if possible, from the volume of any tank or trunk within that space.

Note 1: Where the clear height of the space is less than 2,30 m, the Society may require higher air change rates, with a maximum of:

- 30 changes per hour for enclosed spaces
- 22,5 changes per hour for partially closed spaces.

2.2.3 Fans

a) Ventilation circuits are to be supplied by at least two independent fans of such a capacity as to maintain normal ventilation of all the spaces with one fan out of action.

b) Fans driven by electric motors are to be considered as essential auxiliaries. Their electrical supply is to comply with the provisions of Pt C, Ch 2, Sec 3.

2.3 Fodder and fresh water systems

2.3.1 General

a) Spaces intended for livestock are to be provided with receptacles for feeding and watering the animals concerned.

b) The capacity of the receptacles is not to be less than 33% of the daily consumption of the animals concerned, except when the feed system is automatic.

Table 1 : Documents to be submitted

Item No.	Description of the document **(1)**
1	Diagram of the ventilation system, with indication of the gross volume of the enclosed spaces
2	Diagram of storage and distribution systems for fodder and water
3	Diagram of the water cleaning system
4	Diagram of the drainage system

(1) Diagrams are also to include, where applicable:
- the (local and remote) control and monitoring systems and automation systems
- the instructions for the operation and maintenance of the piping system concerned (for information).

2.3.2 Fresh water system

a) The fresh water system serving the livestock spaces is to be totally independent from the fresh water system serving the spaces intended for the crew.

b) All livestock spaces are to be provided with fresh water service.

c) The fresh water system is to include at least:
- one main supply pump, of a capacity sufficient to continuously supply fresh water to the livestock
- one standby pump of at least the same capacity.

Note 1: When the water supply system is not automatic, the standby pump may be replaced by a portable pump ready to be connected to at least one fresh water tank.

d) When the water supply is automatic, water receptacles are to be fitted with:
- means of automatic water level control
- devices to avoid the return of water from the receptacle to the fresh water tank.

2.4 Washing system

2.4.1 A water washing system is to be provided with appropriate connections to wash the livestock spaces.

2.5 Drainage system

2.5.1 General

a) Each space intended for the livestock is to be fitted with a pipe or gutter of sufficient size to drain the sewage and the washing effluents.

b) The drainage system serving the livestock spaces is to be independent from any piping system serving the other spaces of the ship, and in particular from the bilge system.

2.5.2 Materials

The pipes and other components of the draining system are to be made of a material resistant to the corrosion due to the effluents.

2.5.3 Draining pipes and discharges

a) Discharges from livestock spaces are to comply with the provisions Pt C, Ch 1, Sec 10, [8].

b) Where necessary, drainage gutters and upper parts of the draining pipes are to be covered by a strainer plate.

c) Draining pipes from livestock spaces are to discharge into a holding tank, wells or overboard.

Note 1: Overboard discharge is subject to the provisions of MARPOL Annex IV - Regulations for the Prevention of Pollution by Sewage. See also Pt F, Ch 7, Sec 1.

d) Means are to be provided to stop the overboard discharge when the ship is in port.

2.5.4 Holding tanks

a) Holding tanks are to be fitted with means to indicate visually the amount of their content.

b) Drainage tanks and wells are to be accessible from outside livestock pens for inspection and cleaning.

2.5.5 Pumps and ejectors

Pumps and ejectors serving the holding tanks or wells are to be capable of conveying semi-solid matter.

Part E

Service Notations

Chapter 4

BULK CARRIERS

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 *(1/7/2019)*

Ships complying with the requirements of this Chapter are eligible for the assignment of the service notation **bulk carrier ESP** as defined in (Pt A, Ch 1, Sec 2, [4.3.2]), **bulk carrier ESP CSR** (as defined in Pt A, Ch 1, Sec 2, [4.3.3]) and **self-unloading bulk carrier ESP** (as defined in Pt A, Ch 1, Sec 2, [4.3.8]).

1.1.2 *(1/7/2019)*

Ships dealt with in this Chapter are to comply with the applicable requirements stipulated in Part A, Part B, Part C and Part D, and the "Common Structural Rules for Bulk Carriers and Oil Tankers", in addition to the applicable requirements of this Chapter.

1.2 Summary table

1.2.1 *(1/4/2006)*

Tab 1 indicates, for easy reference, the Sections of this Chapter dealing with requirements applicable to ships having the notation **bulk carriers ESP**.

1.2.2 *(1/4/2006)*

Tab 2 indicates, for easy reference, the Sections of this Chapter dealing with requirements applicable to ships having the notation **bulk carrier ESP CSR**.

1.2.3 *(1/7/2019)*

Tab 3 indicates, for easy reference, the Sections of this Chapter dealing with requirements applicable to ships having the notation **self-unloading bulk carrier ESP**.

Table 1 *(1/4/2006)*

Main subject	Reference
Ship arrangement	Sec 2
Hull and stability	Sec 3
Machinery	Sec 4
Electrical installations	**(1)**
Automation	**(1)**
Fire protection, detection and extinction	**(1)**
Intact stability criteria for grain loading	App 1

(1) No specific requirements for **bulk carriers ESP** are given in this Chapter.

Table 2 *(1/4/2006)*

Main subject	Reference
Ship arrangement	**(1)**
Hull	**(1)**
Stability	Sec 3, [2]
Machinery	Sec 4
Electrical installations	**(1)**
Automation	**(1)**
Fire protection, detection and extinction	**(1)**
Intact stability criteria for grain loading	App 1

(1) No specific requirements for **bulk carriers ESP CSR** are given in this Chapter.

Table 3 *(1/7/2019)*

Main subject	Reference
Ship arrangement	**(1)**
Hull	Sec 3, [3], [4], [5]
Stability	**(1)**
Machinery	Sec 4
Electrical installations	**(1)**
Automation	**(1)**
Fire protection, detection and extinction	**(1)**
Intact stability criteria for grain loading	App 1

(1) No specific requirements for **self-unloading bulk carriers ESP** are given in this Chapter.

SECTION 2 SHIP ARRANGEMENT

1 General

1.1 Application

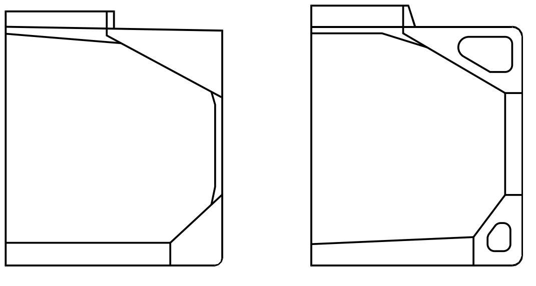
1.1.1 *(1/4/2006)*

The requirements of this Section apply to ships having notation **bulk carrier ESP**. Typical midship sections are shown in Fig 1.

For the purpose of this Chapter, single side skin bulk carrier means a bulk carrier where one or more cargo holds are bound by the side shell only or by two watertight boundaries, one of which is the side shell, which are less than 1000 mm apart in at least one location. The distance between the watertight boundaries is to be measured perpendicular to the side shell.

The application of these requirements to other ship types is to be considered by the Society on a case-by-case basis.

Figure 1 : Bulk carrier
Single and double side skin construction



2 General arrangement design

2.1 Access arrangement to double bottom and pipe tunnel

2.1.1 Means of access

Adequate means of access to the double bottom and the pipe tunnel are to be provided.

2.1.2 Manholes in the inner bottom, floors and girders

Manholes cut in the inner bottom are to be located at a minimum distance of one floor spacing from the lower stool, or transverse bulkhead if no stool is fitted.

The location and size of manholes in floors and girders are to be determined to facilitate the access to double bottom structures and their ventilation. However, they are to be avoided in the areas where high shear stresses may occur.

2.2 Access arrangement to cargo holds

2.2.1 Means of access

As far as practicable, permanent or movable means of access stored on board are to be provided to ensure proper survey and maintenance of cargo holds and, in particular, of the lower part of cargo hold side frames.

2.2.2 Hatches of large cargo holds

If separate hatches are used as access to the ladders as required in [2.2.3], each hatch is to have a clear opening of at least 600 mm x 600 mm.

When the access to the cargo hold is arranged through the cargo hatch, the top of the ladder is to be placed as close as possible to the hatch coaming.

Accesses and ladders are to be so arranged that personnel equipped with self-contained breathing apparatus may readily enter and leave the cargo hold.

Access hatch coamings having a height greater than 900 mm are also to have steps on the outside in conjunction with cargo hold ladders.

2.2.3 Ladders within large cargo holds

Each cargo hold is to be provided with at least two ladders as far apart as practicable longitudinally. If possible these ladders are to be arranged diagonally, e.g. one ladder near the forward bulkhead on the port side, the other one near the aft bulkhead on the starboard side, from the ship's centreline.

Ladders are to be so designed and arranged that the risk of damage from the cargo handling gear is minimised.

Vertical ladders may be permitted provided they are arranged above each other in line with other ladders to which they form access and resting positions are provided at not more than 9 metres apart.

Tunnels passing through cargo holds are to be equipped with ladders or steps at each end of the hold so that personnel may get across such tunnels.

Where it may be necessary for work to be carried out within a cargo hold preparatory to loading, consideration is to be given to suitable arrangements for the safe handling of portable staging or movable platforms.

SECTION 3 HULL AND STABILITY

Symbols

D_1 : Distance, in m, from the base line to the freeboard deck at side amidships (see Fig 13)

h_{DB} : Height, in m, of the double bottom

h_{LS} : Mean height, in m, of the lower stool, measured from the inner bottom

k : Material factor defined in Pt B, Ch 4, Sec 1, [2.3]

t_C : Corrosion addition, in mm, defined in Pt B, Ch 4, Sec 2, Tab 2

ℓ : Span, in m, of side frames; see [3.2.3]

d : Height, in mm, of side frame web; see [3.2.3]

ℓ_C : Span, in m, of the corrugations of vertically corrugated transverse watertight bulkheads; see [3.5.2]

s_C : Spacing of corrugations, in m; see Fig 5

R_{eH} : Minimum upper yield stress, in N/mm^2, of the material as defined in Pt B, Ch 4, Sec 1, [2]

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

- E = 2,06.10^5 N/mm^2 for steels in general
- E = 1,95.10^5 N/mm^2 for stainless steels

ρ_B : Dry bulk cargo density, in t/m^3; the following values may generally be taken:

- ρ_B = 3,0 t/m^3 for iron ore
- ρ_B = 1,3 t/m^3 for cement

φ : Angle of repose, in degrees, of the dry bulk cargo carried; in the absence of more precise evaluation the following values can be taken:

- φ = 30° in general
- φ = 35° for iron ore
- φ = 25° for cement

ρ: Sea water density, in t/m^3

h_F, z_F : Flooding head and distance, respectively, in m, defined in [4.6.3] for transverse bulkheads and [4.7.3] for double bottoms

h_B, z_B : Level height of the dry bulk cargo and distance, respectively, in m, defined in [4.6.4] for transverse bulkheads and [7.2.6] for double bottoms

g : Gravity acceleration, in m/s^2, to be taken equal to 9,81 m/s^2.

1 General

1.1 Application

1.1.1 *(1/4/2006)*

The requirements of this Section apply to ships with the service notation **bulk carrier ESP**.

1.1.2 *(1/4/2006)*

Ships with the service notation **bulk carrier ESP CSR** are to comply with the requirements in [2.1] and [2.2].

1.2 Loading manual and loading instruments

1.2.1 The specific requirements in Pt B, Ch 11, Sec 2 for ships with the service notation **bulk carrier ESP** and equal to or greater than 150 m in length are to be complied with.

2 Stability

2.1 Definitions

2.1.1 Grain

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.

2.1.2 Filled compartment trimmed

The term filled compartment trimmed refers to any cargo space in which, after loading and trimming as specified in App 1, the bulk grain is at its highest possible level.

2.1.3 Filled compartment untrimmed

The term filled compartment untrimmed refers to a cargo space which is filled to the maximum extent possible in way of the hatch opening but which has not been trimmed outside the periphery of the hatch opening.

2.1.4 Partially filled compartment

The term partly filled compartment refers to any cargo space where the bulk grain is not loaded in the manner prescribed in [2.1.2] or [2.1.3].

2.1.5 Stowage factor

The term stowage factor, for the purposes of calculating the grain heeling moment caused by a shift of grain, means the volume per unit weight of the cargo as attested by the loading facility, i.e. no allowance is to be made for lost space when the cargo space is nominally filled.

2.1.6 Specially suitable compartment

The term specially suitable compartment refers to a cargo space which is constructed with at least two vertical or sloping, longitudinal, grain-tight divisions which are coincident with the hatch side girders or are so positioned as to limit the effect of any transverse shift of grain. If sloping, the divisions are to have an inclination of not less than 30° to the horizontal.

2.2 Intact stability

2.2.1 General *(1/7/2010)*

The stability of the ship for the loading conditions in Pt B, Ch 3, App 2, [1.2.5] is to be in compliance with the requirements of Pt B, Ch 3, Sec 2. In addition, for ships engaged in the carriage of grain in bulk, the requirements in [2.2.2] and [2.2.3] are to be complied with.

2.2.2 Grain Loading Manual

Information in printed booklet form is to be provided on board to enable the Master to ensure that the ship complies with the stability requirements reported in the Rules *when carrying grain in bulk.* This booklet is commonly referred to as Grain Loading Manual and *is to include the following information:*

- *ship's particulars*
- *lightship displacement and the vertical distance from the intersection of the moulded base line and midship section to the centre of gravity (KG)*
- *table of liquid free surface corrections*
- *capacities and centres of gravity*
- *curve or table of angle of flooding, where less than 40°, at all permissible displacements*
- *curves or tables of hydrostatic properties suitable for the range of operating drafts*
- *cross curves of stability which are sufficient for the purpose of the requirements in [2.2.3] and which include curves at 12° and 40°*
- *curves or tables of volumes, vertical centres of volumes, and assumed volumetric heeling moments for every hold, filled or partly filled, or combination thereof, including the effects of temporary fittings*
- *tables or curves of maximum permissible heeling moments for varying displacements and varying vertical centres of gravity to allow the Master to demonstrate compliance with* the requirements specified in [2.2.3]
- *loading instructions in the form of notes summarising the requirements of* these Rules
- *a worked example for the guidance of the Master*
- *typical loaded service departure and arrival conditions and, where necessary, intermediate worst service conditions.*

  It is recommended that loading conditions should be provided for at least three representative stowage factors.

The Grain Loading Manual may be drawn up in the official language or languages of the Administration of the issuing country; if the language used is neither English nor French, the text is to include a translation into one of these languages.

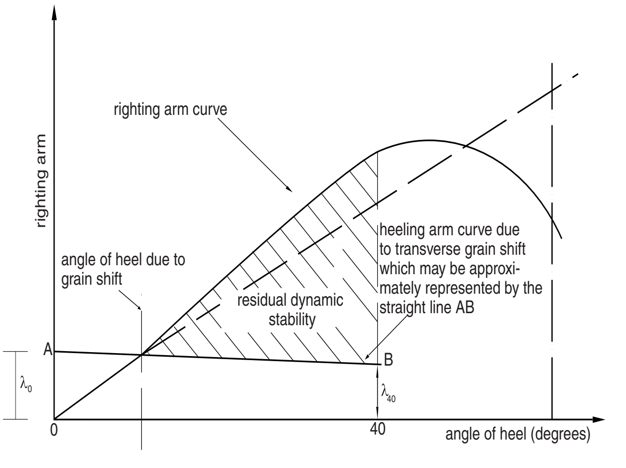
2.2.3 Intact stability criteria for grain loading

The intact stability characteristics of any ship carrying bulk grain are to be shown to meet, throughout the voyage, at least the following criteria after taking into account in the manner described in App 1 and in Fig 2, the heeling moments due to grain shift:

- *the angle of heel due to the shift of grain is to be not greater than 12° or the angle at which the deck edge is immersed, whichever is the lesser*
- *in the statical stability diagram, the net or residual area between the heeling arm curve and the righting arm curve up to the angle of heel of maximum difference between the ordinates of the two curves, or 40° or the angle of flooding, whichever is the least, is in all conditions of loading to be not less than 0,075 m·rad*
- *the initial metacentric height, after correction for the free surface effects of liquids in tanks, as specified in Pt B, Ch 3, Sec 2, [4], is to be not less than 0,30 m.*

After loading, the Master is to ensure that the ship is upright before proceeding to sea.

Figure 1 : Stability curve



3 Structure design principles

3.1 Double bottom structure

3.1.1 Longitudinally framed double bottom

In ships greater than 120 m in length, the double bottom and the sloped bulkheads of hopper tanks are to be longitudinally framed.

The girder spacing is to be not greater than 4 times the spacing of bottom or inner bottom ordinary stiffeners and the floor spacing is to be not greater than 3 frame spaces.

Greater spacing may be accepted by the Society, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo holds.

3.1.2 Transversely framed double bottom

The double bottom and the sloped bulkheads of hopper tanks may be transversely framed in ships equal to or less than 120 m in length, when this is deemed acceptable by the Society on a case-by-case basis. In this case, however, the floor spacing is to be not greater than 2 frame spaces.

3.1.3 Floors in way of transverse bulkheads

The thickness and material properties of the supporting floors and pipe tunnel beams are to be not less than those required for the bulkhead plating or, when a stool is fitted, of the stool side plating.

3.2 Single side structure

3.2.1 General

The side within the hopper and topside tanks is, in general, to be longitudinally framed. It may be transversely framed when this is accepted for the double bottom and the deck according to [3.1.2] and [3.4.1], respectively.

3.2.2 Frame spacing *(1/7/2001)*

In general, the frame spacing in cargo holds bounded by the side shell only is to be not greater than the values obtained, in m, from the following formulae:

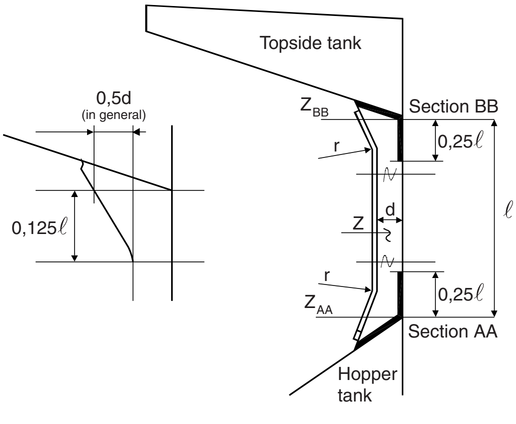
$$s = 0,6 + \frac{L}{320} \qquad \text{for } L < 90\,m$$

$$s = 0,9 + 1,25\left(\frac{L}{100}\right)^{0,25} \qquad \text{for } L \geq 90\,m$$

3.2.3 Frame span and web height

Frame span ℓ and web height d are to be measured as indicated in Fig 2.

Figure 2 : Frame and end bracket geometry



3.2.4 Symmetrical frame sections

Frames are to be fabricated symmetrical sections with integral upper and lower brackets and are to be arranged with soft toes.

The web depth to thickness ratio is to be not greater than 60 $k^{0,5}$. The outstanding flange is to be not greater than 10 $k^{0,5}$ times the flange thickness. The end of the flange is to be snipped.

The frame flange is to be curved (not knuckled) at the connection with the end brackets. The radius of curvature (see Fig 2) is to be not less than the value obtained, in mm, from the following formula:

$$r = \frac{0,4 b_f^2}{t_f}$$

where b_f and t_f are, in mm, the flange width and thickness, respectively.

3.2.5 Asymmetrical frame sections

In ships less than 190 m in length, mild steel frames may be asymmetrical and fitted with overlapped welded brackets. The face plate or flange of the bracket is to be snipped at both ends. Brackets are to be arranged with soft toes.

The web to thickness ratio is to be not greater than 50 $k^{0,5}$. The outstanding flange is to be not greater than 10 $k^{0,5}$ times the flange thickness.

3.2.6 Lower and upper end brackets

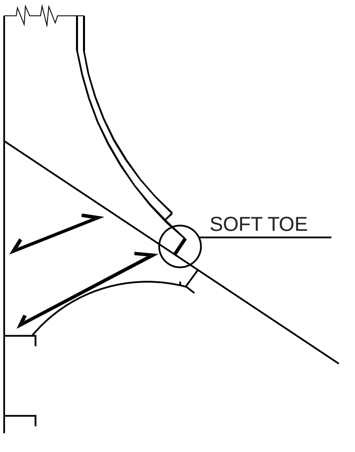
The section modulus of the frame end bracket or integral bracket, calculated, with an attached side plating according to Pt B, Ch 4, Sec 3, [3.3], at the end sections of the span ℓ (sections AA and BB in Fig 2), is to be not less than twice the section modulus required for the frame midspan area according to Pt B, Ch 7, Sec 2 or Pt B, Ch 8, Sec 4, as applicable.

The dimensions of the lower and upper end brackets are to be not less than those shown in Fig 2.

3.2.7 Connecting brackets within hopper and topside tanks

Structural continuity with the upper and lower end connections of side frames is to be ensured within hopper and topside tanks by connecting brackets as shown in Fig 3.

Figure 3 : Connection with bracket within hopper and topside tanks



3.2.8 Tripping brackets

In way of the foremost cargo hold, side frames of asymmetrical section are to be fitted with sloped tripping brackets every two frames, as shown in Fig 4.

In way of the other holds, side frames of asymmetrical sections are to be fitted with sloped tripping brackets every two frames where the web height d is greater than 600 mm or the span ℓ is greater than 6 m.

3.3 Double side structure

3.3.1 General

The side within the hopper and topside tanks is, in general, to be longitudinally framed. It may be transversely framed when this is accepted for the double bottom and the deck according to [3.1.2] and [3.4.1], respectively.

3.3.2 Side primary supporting members

The spacing of transverse side primary supporting members is to be not greater than 3 frame spaces.

Greater spacing may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo holds.

In any case, transverse side primary supporting members are to be fitted in line with web frames in hopper and topside tanks.

3.4 Deck structure

3.4.1 Deck outside the line of hatches and topside tank sloping plates

In ships greater than 120 m in length, the deck outside the line of hatches and the topside tank sloping plates are to be longitudinally framed.

The spacing of web frames in topside tanks is to be not greater than 6 frame spaces.

Greater spacing may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo holds.

3.4.2 Deck between hatches

The cross decks between hatches are generally to be transversely framed.

Connection of the strength deck at side with the deck between hatches is to be ensured by a plate of intermediate thickness.

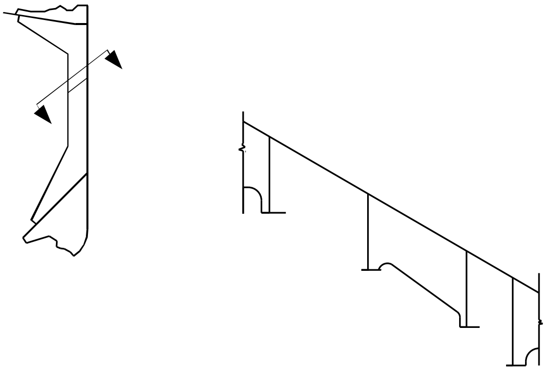
3.4.3 Connection of hatch end beams with deck structures

The connection of hatch end beams with deck structures is to be properly ensured by fitting inside the topside tanks additional web frames or brackets.

3.4.4 Topside tank structure

Topside tank structures are to extend as far as possible within the machinery space and are to be adequately tapered.

Figure 4 : Tripping brackets



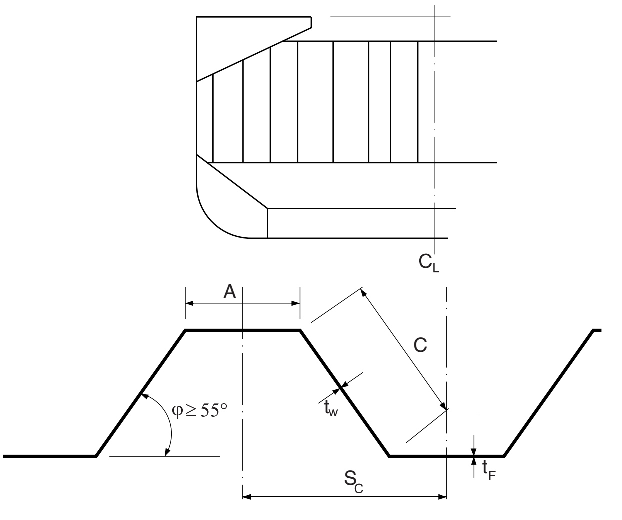
3.5 Transverse vertically corrugated watertight bulkheads

3.5.1 General *(1/7/2004)*

For ships equal to or greater than 190 m in length, transverse vertically corrugated watertight bulkheads are to be fitted with a lower stool and, in general, with an upper stool below the deck. In smaller ships, corrugations may extend from the inner bottom to the deck; if the stool is fitted, it is to comply with the requirements in [3.5.1] to [3.5.5].

The corrugation angle φ shown in Fig 5 is to be not less than 55°.

Figure 5 : Corrugation geometry



The thickness of the lower part of corrugations considered in the application of [3.5.9] and [7.1.3] is to be maintained for a distance from the inner bottom (if no lower stool is fitted) or the top of the lower stool not less than $0,15\ell_C$.

The thickness of the middle part of corrugations considered in the application of [3.5.10] and [7.1.3] is to be maintained for a distance from the deck (if no upper stool is fitted) or the bottom of the upper stool not greater than $0,3\ell_C$.

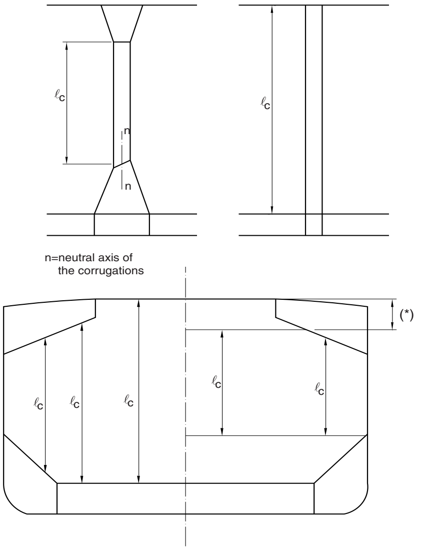
The section modulus of the corrugations in the remaining upper part of the bulkhead is to be not less than 75% of that required for the middle part, corrected for different minimum yield stresses.

3.5.2 Span of corrugations

The span ℓ_C of the corrugations is to be taken as the distance shown in Fig 6. For the definition of ℓ_C, the internal end of the upper stool may not be taken at a distance from the deck at centreline greater than:

- 3 times the depth of corrugations, in general
- twice the depth of corrugations, for rectangular upper stools.

Figure 6 : Span of the corrugations



(*) See [3.5.2].

3.5.3 Lower stool *(1/7/2001)*

The lower stool, when fitted, is to have a height in general not less than 3 times the depth of the corrugations.

The thickness and material of the stool top plate are to be not less than those required for the bulkhead plating above. The thickness and material properties of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top are to be not less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at the lower end of the corrugation.

The ends of stool side ordinary stiffeners are to be attached to brackets at the upper and lower ends of the stool.

The distance from the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with Fig 7.

The stool bottom is to be installed in line with double bottom floors and is to have a width not less than 2,5 times the mean depth of the corrugation.

The stool is to be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate are to be avoided.

Where corrugations are cut at the lower stool, the weld connections of corrugations and stool side plating to the stool top plate are to be in accordance with [12.1]. The weld connections of stool side plating and supporting floors to the inner bottom plating are to be in accordance with [12.1].

3.5.4 Upper stool

The upper stool, when fitted, is to have a height in general between 2 and 3 times the depth of corrugations. Rectangular stools are to have a height in general equal to twice the depth of corrugations, measured from the deck level and at the hatch side girder.

The upper stool is to be properly supported by deck girders or deep brackets between the adjacent hatch end beams.

The width of the upper stool bottom plate is generally to be the same as that of the lower stool top plate. The stool top of non-rectangular stools is to have a width not less than twice the depth of corrugations.

The thickness and material of the stool bottom plate are to be the same as those of the bulkhead plating below. The thickness of the lower portion of stool side plating is to be not less than 80% of that required for the upper part of the bulkhead plating where the same material is used.

The ends of stool side ordinary stiffeners are to be attached to brackets at the upper and lower end of the stool.

The stool is to be fitted with diaphragms in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate are to be avoided.

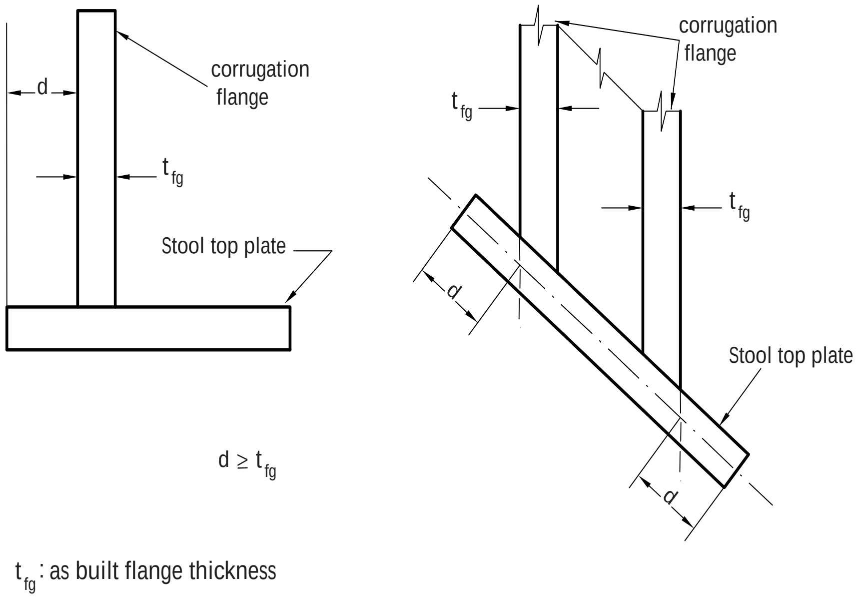
3.5.5 Alignment

At deck, if no upper stool is fitted, two transverse reinforced beams are to be fitted in line with the corrugation flanges.

At bottom, if no lower stool is fitted, the corrugation flanges are to be in line with the supporting floors. The weld connections of corrugations and floors to the inner bottom plating are to be in accordance with [12.1]. The thickness and material properties of the supporting floors are to be not less than those of the corrugation flanges. Moreover, the cut-outs for connections of the inner bottom longitudinals to double bottom floors are to be closed by collar plates. The supporting floors are to be connected to each other by suitably designed shear plates.

Stool side plating is to align with the corrugation flanges; lower stool side vertical stiffeners and their brackets in the stool are to align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Lower stool side plating may not be knuckled anywhere between the inner bottom plating and the stool top plate.

Figure 7 : Permitted distance, d, from the edge of the stool top plate to the surface of the corrugation flange



3.5.6 Effective width of the compression flange

The effective width of the corrugation flange to be considered for the strength check of the bulkhead is to be obtained, in m, from the following formula:

$$b_{EF} = C_E A$$

where:

C_E : Coefficient to be taken equal to:

$$C_E = \frac{2,25}{\beta} - \frac{1,25}{\beta^2} \quad \text{for } \beta > 1,25$$

$$C_E = 1,0 \quad \text{for } \beta \leq 1,25$$

β : Coefficient to be taken equal to:

$$\beta = 10^3 \frac{A}{t_f}\sqrt{\frac{R_{eH}}{E}}$$

A : Width, in m, of the corrugation flange (see Fig 5)

t_f : Net flange thickness, in mm.

3.5.7 Effective shedder plates

Effective shedder plates are those which:

- are not knuckled
- are welded to the corrugations and the lower stool top plate according to [12.1]
- are fitted with a minimum slope of 45°, their lower edge being in line with the lower stool side plating
- have thickness not less than 75% of that required for the corrugation flanges
- have material properties not less than those required for the flanges.

3.5.8 Effective gusset plates

Effective gusset plates are those which:

- are in combination with shedder plates having thickness, material properties and welded connections according to [3.5.7]
- have a height not less than half of the flange width
- are fitted in line with the lower stool side plating
- are welded to the lower stool plate, corrugations and shedder plates according to [12.1]
- have thickness and material properties not less than those required for the flanges.

3.5.9 Section modulus at the lower end of corrugations

a) The section modulus at the lower end of corrugations (sections 1 in Fig 8 to Fig 12) is to be calculated with the compression flange having an effective flange width b_{ef} not larger than that indicated in [3.5.6] .

b) Webs not supported by local brackets.

Except in case e), if the corrugation webs are not supported by local brackets below the stool top plate (or below the inner bottom) in the lower part, the section modulus of the corrugations is to be calculated considering the corrugation webs 30% effective.

c) Effective shedder plates.

Provided that effective shedder plates, as defined in [3.5.7], are fitted (see Fig 8 and Fig 9), when calculating the section modulus of corrugations at the lower end (sections 1 in Fig 8 and Fig 9), the area of flange plates may be increased by the value obtained, in cm^2, from the following formula:

$$I_{SH} = 2,5A\sqrt{t_F t_{SH}}$$

without being taken greater than $2,5At_F$,

where:

A : Width, in m, of the corrugation flange (see Fig 5)

t_{SH} : Net shedder plate thickness, in mm

t_F : Net flange thickness, in mm.

Figure 8 : Symmetrical shedder plates

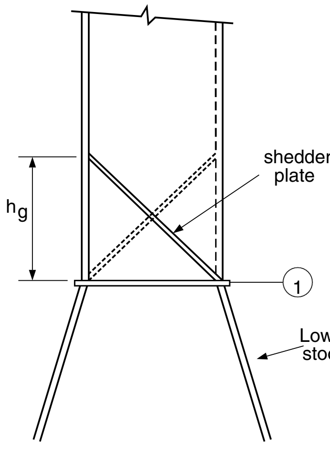
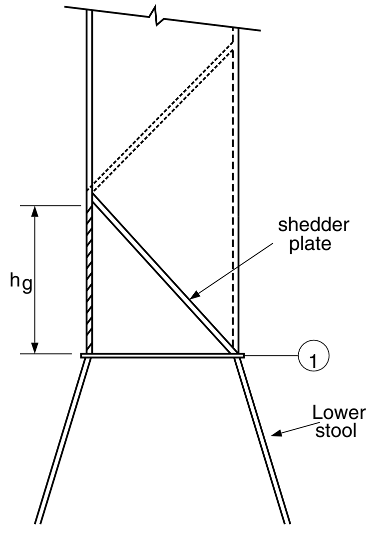


Figure 9 : Asymmetrical shedder plates



d) Effective gusset plates.

Provided that effective gusset plates, as defined in [3.5.8], are fitted (see Fig 10 to Fig 12), when calculating the section modulus of corrugations at the lower end (cross-sections 1 in Fig 10 to Fig 12), the area of flange plates may be increased by the value obtained, in cm^2, from the following formula:

$$I_G = 7h_G t_F$$

where:

h_G : Height, in m, of gusset plates (see Fig 10 to Fig 12), to be taken not greater than $(10/7)S_{GU}$

S_{GU} : Width, in m, of gusset plates

t_F : Net flange thickness, in mm, based on the as-built condition.

Figure 10 : Symmetrical gusset/shedder plates

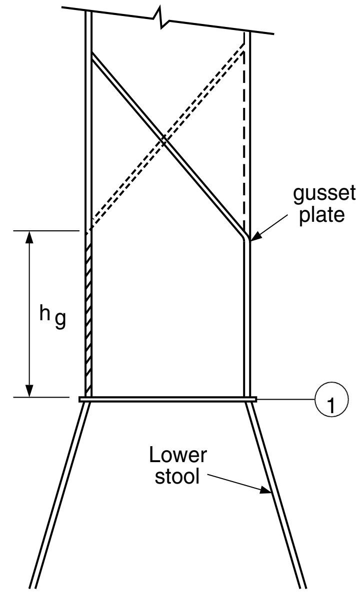
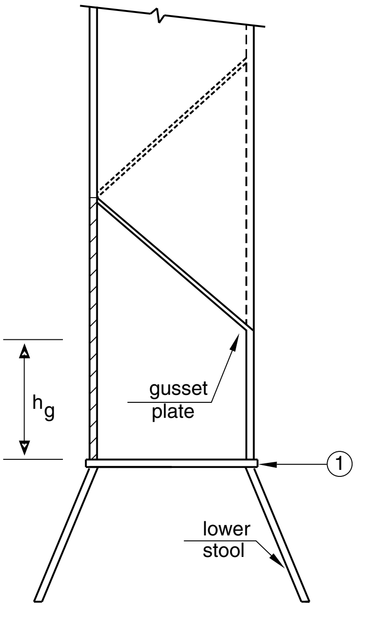


Figure 11 : Asymmetrical gusset/shedder plates

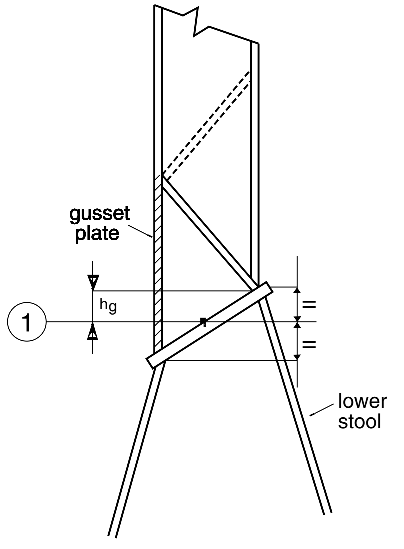


e) Sloping stool top plate

If the corrugation webs are welded to a sloping stool top plate which has an angle not less than 45° with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. For angles less than 45°, the effectiveness of the web may be obtained by linear interpolation between 30% for 0° and 100% for 45°.

Where effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in d) above. No credit may be given to shedder plates only.

Figure 12 : Asymmetrical gusset/shedder plates Sloping stool top plate



3.5.10 Section modulus at sections other than the lower end of corrugations

The section modulus is to be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{EF}, not larger than that obtained in [3.5.6].

3.5.11 Shear area

The shear area is to be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin φ), φ being the angle between the web and the flange (see Fig 5).

4 Design loads

4.1 Hull girder loads

4.1.1 Application *(1/7/2003)*

In addition to the requirements in Pt B, Ch 5, Sec 2, [2.1.2], still water loads are to be calculated for the loading conditions specified in [4.2] and in [4.3].

For the purpose of applying the requirements in [4.2] and in [4.3], maximum draught is to be taken as moulded summer load line draught.

4.1.2 General *(1/7/2003)*

A bulk carrier may in actual operation be loaded differently from the design loading conditions specified in the loading manual, provided that limitations for longitudinal and local strength as defined in the loading manual and loading instrument on board and applicable stability requirements are not exceeded.

4.1.3 Departure and arrival conditions *(1/7/2003)*

Unless otherwise specified, each of the design loading conditions defined in [4.2] and in [4.3] is to be investigated for the arrival and departure conditions, defined as:

- Departure condition: with bunker tanks not less than 95% full and other consumables 100%
- Arrival condition: with 10% of consumables.

4.2 Hull girder loads in cargo loaded conditions

4.2.1 Still water loads for ships with additional service feature BC-C *(1/7/2003)*

Still water hull girder loads are to be calculated in homogeneous cargo loaded condition, where the cargo density corresponds to all cargo holds, including hatchways, being 100% full at maximum draught with all ballast tanks empty.

4.2.2 Still water loads for ships with additional service feature BC-B *(1/7/2003)*

Still water hull girder loads are to be calculated in the following loading conditions:

- homogeneous cargo loaded condition, as specified in [4.2.1]
- homogeneous cargo loaded condition with cargo density 3,0 t/m³, and the same filling rate (cargo mass/hold cubic capacity) in all cargo holds at maximum draught with all ballast tanks empty.

  In cases where the cargo density applied for this design loading condition is less than 3,0 t/m³, the maximum density of the cargo that the vessel is allowed to carry is to be indicated with the additional service feature **maximum cargo density** (in t/m³).

4.2.3 Still water loads for ships with additional service feature BC-A *(1/7/2003)*

Still water hull girder loads are to be calculated in the following loading conditions:

- homogeneous cargo loaded conditions, as specified in [4.2.2]
- at least one cargo loaded condition with specified holds empty, with cargo density 3,0 t/m³, and the same filling rate (cargo mass/hold cubic capacity) in all loaded cargo holds at maximum draught with all ballast tanks empty.

  The combination of specified empty holds is to be indicated with the additional service feature **allowed combination of specified empty holds**.

  In such cases where the design cargo density applied is less than 3,0 t/m³, the maximum density of the cargo that the vessel is allowed to carry is to be indicated within the annotation, e.g. additional service feature **allowed combination of specified empty holds, with maximum cargo density** (in t/m³).

4.2.4 Partly filled ballast tanks in cargo loaded conditions *(1/7/2003)*

For cargo loading conditions involving partially filled peak and/or other ballast tanks, the requirements specified in Pt B, Ch 5, Sec 2, [2.1.2], b) apply to the peak tanks only.

4.3 Hull girder loads in ballast conditions

4.3.1 Ballast tank capacity and disposition *(1/7/2003)*

All bulk carriers are to have ballast tanks of sufficient capacity and so disposed as to fulfil the following requirements in [4.3.2] and in [4.3.3].

4.3.2 Normal ballast condition *(1/7/2003)*

Still water hull girder loads are to be calculated for normal ballast condition. Normal ballast condition is a ballast (no cargo) condition where:

- the ballast tanks may be full, partially full or empty. Where the partially full option is exercised, the requirements in Pt B, Ch 5, Sec 2, [2.1.2], b) are to be complied with
- any cargo hold or holds adapted for the carriage of water ballast at sea are empty
- the propeller is fully immersed, and
- the trim is by the stern and does not exceed $0,015L_{LL}$, where L_{LL} is the length between perpendiculars of the ship, defined in Pt B, Ch 1, Sec 2, [3.2].

In the assessment of the propeller immersion and trim, the draughts at the forward and aft perpendiculars may be used.

In addition to the requirements specified above, still water hull girder loads are to be calculated by considering a condition with all ballast tanks 100 % full.

4.3.3 Heavy ballast condition *(1/7/2003)*

Still water hull girder loads are to be calculated for heavy ballast condition. Heavy ballast condition is a ballast (no cargo) condition where:

a) the ballast tanks may be full, partially full or empty. Where the partially full option is exercised, the requirements in Pt B, Ch 5, Sec 2, [2.1.2], b) are to be complied with,

b) at least one cargo hold adapted for carriage of water ballast at sea, where required or provided, is full

c) the propeller immersion I/D is to least 60% where:
   - I = the distance from propeller centreline to the waterline
   - D = propeller diameter

d) the trim is by the stern and does not exceed $0,015L_{LL}$, where L_{LL} is the length between perpendiculars of the ship, defined in Pt B, Ch 1, Sec 2, [3.2]

e) the moulded forward draught in the heavy ballast condition is not less than the lesser of 0,03L or 8 m.

In addition to the requirements specified above, still water hull girder loads are to be calculated for a condition with all ballast tanks 100 % full and one cargo hold adapted and designated for the carriage of water ballast at sea, where provided, 100 % full; where more than one hold is adapted and designated for the carriage of water ballast at sea, two or more holds are not required to be assumed 100 % full simultaneously in the still water hull girder load calculation, except where this is expected in the heavy ballast condition. Unless each hold is individually investigated, the designated heavy ballast hold and any/all restrictions for the use of other ballast hold(s) are to be indicated in the loading manual.

4.4 Hull girder loads in flooded conditions of bulk carriers equal to or greater than 150m in length

4.4.1 Application *(1/7/2014)*

These requirements apply, in addition to those in Pt B, Ch 6, Sec 2, to bulk carriers of 150 m in length and upwards, intending to carry solid bulk cargoes having a density of 1,0 t/m^3 or above, and with:

a) Single side skin construction, or

b) Double side skin construction in which any part of the longitudinal bulkhead is located within B/5 or 11,5 m, whichever is less, inboard from the ship's side at right angles to the centreline at the assigned summer load line.

4.4.2 Flooding assumptions *(1/7/2019)*

Each cargo hold is to be considered individually flooded up to the equilibrium waterline. This application is to be applied to self-unloading bulk carriers where the unloading system maintains the watertightness during seagoing operations. In self-unloading bulk carriers with unloading systems that do not maintain watertightness, the longitudinal strength the flooded conditions are to be considered using the extent to which the flooding may occur.

In calculating the weight of ingressed water, the following assumptions are to be made.

Appropriate permeabilities and bulk densities are to be used for any cargo carried. For iron ore, a minimum permeability of 0,3 with a corresponding bulk density of 3,0 t/m^3 is to be used. For cement, a minimum permeability of 0,3 with a corresponding bulk density of 1,3 t/m^3 is to be used. In this respect, “permeability” for dry bulk cargo means the ratio of the floodable volume between the particles, granules or any larger pieces of the cargo, to the gross volume of the bulk cargo.

The permeability of empty cargo spaces and volume left in loaded cargo spaces above any cargo is to be taken equal to 0,95.

For packed cargo conditions (such as in the case of steel mill products), the actual density of the cargo is to be used with a permeability of zero.

4.4.3 Still water hull girder loads *(1/7/2003)*

The still water loads in flooded conditions are to be calculated for each of the cargo and ballast conditions considered in the intact longitudinal strength calculations, as specified in [4.1], [4.2] and [4.3].

4.4.4 Wave hull girder loads *(1/7/2003)*

The wave loads in flooded conditions are to be assumed to be equal to 80% of those defined in Pt B, Ch 5, Sec 2, [3.1].

4.5 Internal pressures and forces due to dry bulk cargoes

4.5.1 Application *(1/7/2003)*

The requirements in [4.5] apply for the evaluation of the cargo mass to be considered for calculating still water and wave pressures and forces due to dry bulk cargoes.

4.5.2 Definitions *(1/7/2003)*

The maximum allowable or minimum required cargo mass in a cargo hold, or in two adjacently loaded holds, is related to the net load on the double bottom. The net load on the double bottom is a function of draft, cargo mass in the cargo hold, as well as the mass of fuel oil and ballast water contained in double bottom tanks.

The following definitions apply:

M_H : the actual cargo mass in a cargo hold corresponding to a homogeneously loaded condition at maximum draught.

M_{Full} : the cargo mass in a cargo hold corresponding to cargo with virtual density (homogeneous mass/hold cubic capacity, minimum 1,0 t/m^3) filled to the top of the hatch coaming. M_{Full} is in no case to be less than M_H.

M_{HD} : the maximum cargo mass allowed to be carried in a cargo hold according to design loading condition(s) with specified holds empty at maximum draft.

4.5.3 General conditions applicable for all ships *(1/7/2003)*

Any cargo hold is to be capable of carrying M_{Full} with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at maximum draught.

Any cargo hold is to be capable of carrying minimum 50% of M_H, with all double bottom tanks in way of the cargo hold being empty, at maximum draught.

Any cargo hold is to be capable of being empty, with all double bottom tanks in way of the cargo hold being empty, at the deepest ballast draught.

4.5.4 Condition applicable for all notations, except when the ship is assigned with the additional service feature no MP *(1/7/2003)*

Any cargo hold is to be capable of carrying M_{Full} with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at 67% of maximum draught.

Any cargo hold is to be capable of being empty with all double bottom tanks in way of the cargo hold being empty, at 83% of maximum draught.

Any two adjacent cargo holds are to be capable of carrying M_{Full} with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at 67% of the maximum draught. This requirement for the mass of cargo and fuel oil in double bottom tanks in way of the cargo hold also applies to the condition where the adjacent hold is filled with ballast, if applicable.

Any two adjacent cargo holds are to be capable of being empty, with all double bottom tanks in way of the cargo hold being empty, at 75% of maximum draught.

4.5.5 Additional conditions applicable to ship with additional service feature BC-A only *(1/7/2003)*

Cargo holds, which are intended to be empty at maximum draught, are to be capable of being empty with all double bottom tanks in way of the cargo hold also being empty.

Cargo holds, which are intended to be loaded with high density cargo, are to be capable of carrying M_{HD} plus 10% of M_H, with fuel oil tanks in the double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom being empty in way of the cargo hold, at maximum draught. In operation the maximum allowable cargo mass is to be limited to M_{HD}.

Any two adjacent cargo holds which, according to a design loading condition, may be loaded with the next holds being empty, are to be capable of carrying 10% of M_H in each hold in addition to the maximum cargo load according to that design loading condition, with fuel oil tanks in the double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at maximum draught. In operation the maximum allowable mass is to be limited to the maximum cargo load according to the design loading conditions.

4.5.6 Additional conditions applicable for ballast holds only *(1/7/2003)*

Cargo holds which are designed as ballast water holds are to be capable of being 100% full of ballast water including hatchways, with all double bottom tanks in way of the cargo hold being 100% full, at any heavy ballast draught. For ballast holds adjacent to topside wing, hopper and double bottom tanks, it is strengthwise acceptable that the ballast holds are filled when the topside wing, hopper and double bottom tanks are empty.

4.5.7 Additional conditions applicable during loading and unloading in harbour only *(1/7/2003)*

Any single cargo hold is to be capable of holding the maximum allowable seagoing mass at 67% of maximum draught, in harbour condition.

Any two adjacent cargo holds are to be capable of carrying M_{Full}, with fuel oil tanks in the double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at 67% of maximum draught, in harbour condition.

At reduced draught during loading and unloading in harbour, the maximum allowable mass in a cargo hold may be increased by 15% of the maximum mass allowed at the maximum draught in seagoing condition, but may not exceed the mass allowed at maximum draught in the seagoing condition. The minimum required mass may be reduced by the same amount.

4.5.8 Hold mass curves *(1/7/2003)*

Based on the design loads for local strength, as specified in [4.5.1] to [4.5.7], except [4.5.6], hold mass curves are to be included in the loading manual and the loading instrument, showing maximum allowable and minimum required mass as a function of draught, in seagoing condition as well as during loading and unloading in harbour (See Pt B, Ch 11, Sec 2).

At draughts other than those specified in the design loading conditions above, the maximum allowable and minimum required mass are to be adjusted for the change in buoyancy acting on the bottom. Change in buoyancy is to be calculated using water plane area at each draught.

Hold mass curves for each single hold, as well as for any two adjacent holds, are to be included.

4.6 Local loads in flooding conditions on transverse vertically corrugated watertight bulkheads of bulk carriers equal to or greater than 150 m in length

4.6.1 Application *(1/7/2014)*

These requirements apply, in lieu of those in Pt B, Ch 5, Sec 6, [9], to all bulk carriers with transverse vertically corrugated watertight bulkheads and which are of 150 m in length and upwards, intending to carry solid bulk cargoes having a density of 1,0 t/m^3 or above, and with:

a) Single side skin construction, or

b) Double side skin construction in which any part of the longitudinal bulkhead is located within B/5 or 11,5 m, whichever is less, inboard from the ship's side at right angles to the centreline at the assigned summer load line.

Each cargo hold is to be considered individually flooded.

4.6.2 General *(1/7/2019)*

The loads to be considered as acting on each bulkhead are those given by the combination of those induced by cargo loads with those induced by the flooding of one hold adjacent to the bulkhead under examination. In any case, the pressure due to the flooding water alone is to be considered.

This application is to be applied to self-unloading bulk carriers where the unloading system maintains the watertightness during seagoing operations. In self-unloading bulk carriers with unloading systems that do not maintain watertightness, the combination loads acting on the bulkheads in the flooded conditions are to be considered using the extent to which the flooding may occurs.

The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of each bulkhead, depending on the loading conditions included in the loading manual:

- homogeneous loading conditions
- non-homogeneous loading conditions,

considering the individual flooding of both loaded and empty holds.

For the purpose of this item, homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, does not exceed 1,20, to be corrected for different cargo densities.

Non-homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not be considered according to these requirements.

The specified design load limits for the cargo holds are to be represented by loading conditions defined by the Designer in the loading manual.

For the purpose of this item, holds carrying packed cargoes are to be considered as empty holds for this application.

Unless the ship is intended to carry, in non-homogeneous conditions, only iron ore or cargo having bulk density equal to or greater than 1,78 t/m^3, the maximum mass of cargo which may be carried in the hold is also to be considered to fill that hold up to the upper deck level at centreline.

4.6.3 Flooding head

The flooding head h_F (see Fig 13) is the distance, in m, measured vertically with the ship in the upright position, from the calculation point to a level located at a distance z_F, in m, from the base line equal to:

- in general:
  - D_1 for the foremost transverse corrugated bulkhead
  - $0,9D_1$ for other bulkheads;

  where the ship is to carry cargoes having bulk density less than 1,78 t/m^3 in non-homogeneous loading conditions, the following values may be assumed:
  - $0,95D_1$ for the foremost transverse corrugated bulkhead
  - $0,85D_1$ for other bulkheads
- for ships less than 50000 t deadweight with type B freeboard:
  - $0,95D_1$ for the foremost transverse corrugated bulkhead
  - $0,85D_1$ for other bulkheads;

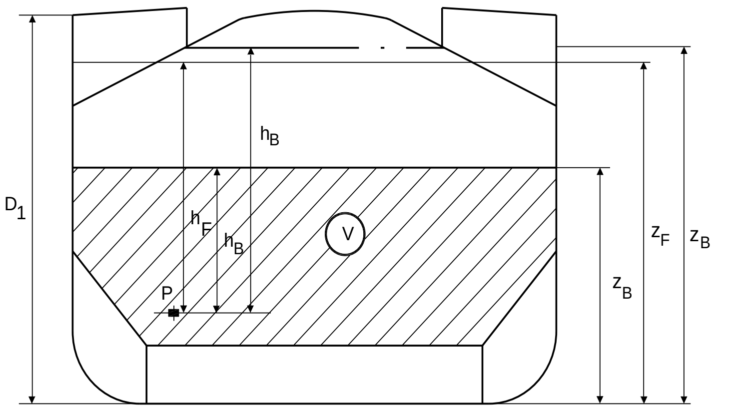
  where the ship is to carry cargoes having bulk density less than 1,78 t/m^3 in non-homogeneous loading conditions, the following values may be assumed:
  - $0,9D_1$ for the foremost transverse corrugated bulkhead
  - $0,8D_1$ for other bulkheads.

4.6.4 Level height of the dry bulk cargo

The level height of the dry bulk cargo h_B, is the vertical distance, in m, from the calculation point to the horizontal plane corresponding to the level height of the cargo, located at a distance z_B (see Fig 13), from the base line.

In the absence of more precise information, z_B may be obtained according to Pt B, Ch 5, Sec 6, [3.1.2].

Figure 13 : Transverse bulkheads - Flooding head and level height of the dry bulk cargo



V=Volume of cargo
P=Calculation point

4.6.5 Pressures and forces on a corrugation in non-flooded bulk cargo loaded holds

At each point of the bulkhead, the pressure is to be obtained, in kN/m², from the following formula:

$$p_B = \rho_B\ g\ z_B\ \tan^2\left(45 - \frac{\varphi}{2}\right)$$

The force acting on a corrugation is to be obtained, in kN, from the following formula:

$$F_B = \rho_B\ g\ s_C\ \frac{(z_B - h_{DB} - h_{LS})^2}{2} \tan^2\left(45 - \frac{\varphi}{2}\right)$$

4.6.6 Pressures and forces on a corrugation in flooded bulk cargo loaded holds

Two cases are to be considered, depending on the values of z_F and z_B (see [4.6.3] and [4.6.4]):

- $z_F \geq z_B$

  At each point of the bulkhead located at a distance between z_B and z_F from the base line, the pressure, in kN/m², is to be obtained from the following formula:

  $$p_{B,F} = \rho g h_F$$

  At each point of the bulkhead located at a distance lower than z_B from the base line, the pressure, in kN/m², is to be obtained from the following formula:

  $$p_{B,F} = \rho\ g\ h_F + [\rho_B - \rho(1 - perm)]g\ h_B\ \tan^2\left(45 - \frac{\varphi}{2}\right)$$

  where perm is the permeability of cargo, to be taken as 0,3 for iron ore, coal cargoes and cement.

  The force acting on a corrugation is to be obtained, in kN, from the following formula:

  $$F_{B,F} = s_C\left[\rho g \frac{(z_F - z_B)^2}{2} + \frac{\rho g(z_F - z_B) + (p_{B,F})_{LE}}{2}(z_B - h_{DB} - h_{LS})\right]$$

  where $(p_{B,F})_{LE}$ is the pressure $p_{B,F}$, in kN/m², calculated at the lower edge of the corrugation.

- $z_F < z_B$

  At each point of the bulkhead located at a distance between z_F and z_B from the base line, the pressure is to be obtained, in kN/m², from the following formula:

  $$p_{B,F} = \rho_B\ g\ z_B\ \tan^2\left(45 - \frac{\varphi}{2}\right)$$

  At each point of the bulkhead located at a distance lower than z_F from the base line, the pressure is to be obtained, in kN/m², from the following formula:

  $$p_{B,F} = \rho\ g\ h_F + [\rho_B\ h_B - \rho\ (1\text{-}perm)\ h_F]\ g\ \tan^2\left(45 - \frac{\varphi}{2}\right)$$

  where perm is the permeability of cargo, to be taken as 0,3 for iron ore, coal cargoes and cement.

  The force acting on a corrugation is to be obtained, in kN, from the following formula:

  $$F_{B,F} = s_C\left[\rho_B\ g\ \frac{(z_B - z_F)^2}{2} \tan^2\left(45 - \frac{\varphi}{2}\right)\right] + s_C\left[\frac{\rho_B g(z_B - z_F)\tan^2\left(45 - \frac{\varphi}{2}\right) + (p_{B,F})_{LE}}{2}(z_F - h_{DB} - h_{LS})\right]$$

  where $(p_{B,F})_{LE}$ is the pressure $p_{B,F}$, in kN/m², calculated at the lower edge of the corrugation.

4.6.7 Pressures and forces on a corrugation in flooded empty holds

At each point of the bulkhead, the still water pressure induced by the flooding head h_F to be considered is to be obtained, in kN/m², from the following formula:

$$p_F = \rho\ g\ h_F$$

The force acting on a corrugation is to be obtained, in kN, from the following formula:

$$F_F = s_C\ \rho\ g\ \frac{(z_F - h_{DB} - h_{LS})^2}{2}$$

4.6.8 Resultant pressures and forces

Resultant pressures and forces to be calculated for homogeneous and non-homogeneous loading conditions are to be obtained according to the following formulae:

- Homogeneous loading conditions

  At each point of the bulkhead structures, the resultant pressure to be considered for the scantlings of the bulkhead is to be obtained, in kN/m², from the following formula:

  $$p = p_{B,F} - 0{,}8 p_B$$

  The resultant force acting on a corrugation is to be obtained, in kN, from the following formula:

  $$F = F_{B,F} - 0{,}8 F_B$$

  where:

  p_B : Pressure in the non-flooded holds, in kN/m², to be obtained as specified in [4.6.5]

  $p_{B,F}$: Pressure in the flooded holds, in kN/m², to be obtained as specified in [4.6.6]

  $F_{B,F}$: Force acting on a corrugation in the flooded holds, in kN, to be obtained as specified in [4.6.6].

- Non-homogeneous loading conditions

  At each point of the bulkhead structures, the resultant pressure to be considered for the scantlings of the bulkhead is to be obtained, in kN/m², by the following formula:

  $$p = p_{B,F}$$

  The resultant force acting on a corrugation is to be obtained, in kN, by the following formula:

  $$F = F_{B,F}$$

  where:

  $p_{B,F}$: Pressure in the flooded holds kN/m², to be obtained as specified in [4.6.6]

  $F_{B,F}$: Force acting on a corrugation in the flooded holds kN/m², to be obtained as specified in [4.6.6].

4.6.9 Bending moment, shear force and shear stresses in a corrugation

The design bending moment in a corrugation is to be obtained, in kN.m, from the following formula:

$$M = \frac{F \ell_C}{8}$$

where F is the resultant force, in kN, to be calculated according to [4.6.8].

The design shear force in a corrugation is to be obtained, in kN, from the following formula:

$$Q = 0{,}8F$$

The shear stresses in a corrugation are to be obtained, in N/mm², from the following formula:

$$\tau = 10 \frac{Q}{A_{SH}}$$

where A_{SH} is the shear area, in cm², to be calculated according to [3.5.11].

4.7 Local loads in flooding conditions on the double bottom of single side skin bulk carriers equal to or greater than 150 m in length

4.7.1 Application *(14/2006)*

These requirements apply, in lieu of those in Pt B, Ch 5, Sec 6, [9], to all bulk carriers equal to or greater than 150 m in length, intended for the carriage of bulk cargoes having dry bulk density 1,0 t/m³ or above.

Each cargo hold is to be considered individually flooded.

4.7.2 General

The loads to be considered as acting on the double bottom are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of the hold which the double bottom belongs to.

The most severe combinations of cargo induced loads and flooding loads are to be used, depending on the loading conditions included in the loading manual:

- homogeneous loading conditions
- non-homogeneous loading conditions
- packed cargo conditions (such as in the case of steel mill products).

For each loading condition, the maximum dry bulk cargo density to be carried is to be considered in calculating the allowable hold loading.

4.7.3 Flooding head

The flooding head h_F (see Fig 14) is the distance, in m, measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance z_F, in m, from the base line equal to:

- in general:
  - D_1 for the foremost hold
  - $0{,}9D_1$ for other holds.
- for ships less than 50000 t deadweight with type B freeboard:
  - $0{,}95D_1$ for the foremost hold
  - $0{,}85D_1$ for other holds.

4.8 Additional requirements on local loads for ships with the additional service feature heavycargo

4.8.1 Application

For ships with a service notation completed by the additional service feature **heavycargo [HOLDi, Xi kN/m², ρi kN/m³ - HATCHi, Yi kN/m²]** (see Pt A, Ch 1, Sec 2, [4.3.2]), the values Xi and ρi, relevant to bulk cargoes carried in holds, and Yi, relevant to uniform cargoes carried on hatch covers, are to be taken according to [4.8.2] and [4.8.3], respectively.

4.8.2 Characteristics of bulk cargoes carried in holds *(1/7/2005)*

ρi is, for each hold, the mass density of the cargo which fills the hold up to the upper deck level at centreline for the maximum mass which may be carried in that hold; ρi is to be defined by the Designer and is to be greater than 1,0 t/m^3.

Xi is the maximum allowable local pressure on the inner bottom of each hold and is to be specified by the Designer. In any case, it is to be not less than the value obtained, for each hold, from the formula for p_S on the inner bottom in Pt B, Ch 5, Sec 6, [3.1.1], where the hold is to be considered as being completely filled and ρ_B is to be taken equal to ρi defined above.

4.8.3 Characteristics of uniform cargoes carried on hatch covers *(1/7/2005)*

Yi is the maximum allowable local pressure on each hatch cover and is to be specified by the Designer. For each hatch cover, it is to be taken as the p_S value in Pt B, Ch 5, Sec 6, [4.1.1] for the hatch cover scantling. Yi is to be greater than 10 kN/m^2.

4.9 Loading conditions for primary structure analysis

4.9.1 The following loading conditions are to be considered in the analysis of the primary structure:

- homogeneous loading
- alternate loading, the loaded hold being completely filled with cargo
- alternate loading, the cargo density being the minimum obtained from the loading booklet, but taken not less than 3 t/m^3
- heavy ballast, the ballast hold being full.

Unless otherwise specified, these loading conditions are to be associated with the ship in upright conditions.

5 Hull girder strength

5.1 Hull girder strength in flooded conditions of bulk carriers equal to or greater than 150m in length

5.1.1 Application *(1/7/2014)*

These requirements apply, in addition to those in Pt B, Ch 6, Sec 2, to bulk carriers of 150 m in length and upwards, intending to carry solid bulk cargoes having a density of 1,0 t/m^3 or above, and with:

a) Single side skin construction, or

b) Double side skin construction in which any part of the longitudinal bulkhead is located within B/5 or 11,5 m, whichever is less, inboard from the ship's side at right angles to the centreline at the assigned summer load line.

Such ships are to have their hull girder strength checked for specified flooded conditions, in each of the cargo and ballast loading conditions defined in Pt B, Ch 6, Sec 2, [2.1] and in [4.1], [4.2] and [4.3], and in every other condition considered in the intact longitudinal strength calculations, including those included in the loading manual, according to Pt B, Ch 11, Sec 2, except that harbour conditions, docking condition afloat, loading and unloading transitory conditions in port and loading conditions encountered during ballast water exchange need not be considered.

The damaged structure is assumed to remain fully effective in resisting the applied loading.

5.1.2 Stresses *(1/4/2006)*

The normal stresses at any point are to be obtained, in N/mm^2, from the following formula:

$$\sigma_{1F} = \frac{M_{SW,F} + M_{WV,F}}{Z_A} 10^3$$

where:

$M_{SW,F}$: Still water bending moment, in kNm, in flooded conditions, at the hull transverse section under consideration, to be calculated according to [4.4]

$M_{WV,F}$: Vertical wave bending moment, in kNm, in flooded conditions, at the hull transverse section under consideration, to be taken, according to [4.4], equal to:

- in hogging conditions:

  $M_{WV,F} = 0,8 M_{WV,H}$

- in sagging conditions:

  $M_{WV,F} = 0,8 M_{WV,S}$

$M_{WV,H}$, $M_{WV,S}$: Vertical wave bending moments, in kN.m, in hogging and sagging conditions, at the hull transverse section under consideration, defined in Pt B, Ch 5, Sec 2, [3.1]

Z_A : Section modulus, in cm^3, at the considered point of the hull girder.

The shear stresses at any point are to be obtained, in N/mm^2, from the following formula:

$$\tau_{1F} = \delta(Q_{SW,F} + Q_{WV,F} - \varepsilon \Delta Q_C)\frac{S}{I_Y t}$$

where:

δ : Shear distribution coefficient defined in Tab 2

$Q_{SW,F}$: Still water shear force, in kN, in flooded conditions, at the hull transverse section under consideration, to be calculated according to [4.4]

$Q_{WV,F}$: Vertical wave shear force, in kN, in flooded conditions, at the hull transverse section under consideration, to be taken, according to [4.4], equal to:

$Q_{WV,F} = 0,8 Q_{WV}$

Q_{WV} : Vertical wave shear force, in kN, at the hull transverse section under consideration, defined in Pt B, Ch 5, Sec 2, [3.4]

$\varepsilon = \text{sgn}(Q_{SW,F})$

ΔQ_C : Shear force correction, in kN, to be calculated according to Pt B, Ch 6, Sec 2, [2.4.1], where the mass P is to include the mass of the ingressed water in the hold considered and the draught T_1 is to be measured up to the equilibrium waterline

I_Y : Moment of inertia, in m^4, of the hull transverse section around its horizontal neutral axis, to be calculated according to Pt B, Ch 6, Sec 1, [2.4]

S : First moment, in m^3, of the hull transverse section around its horizontal neutral axis, to be calculated according to Pt B, Ch 6, Sec 1, [2.5]

t : Thickness, in mm, of the side plating.

5.1.3 Checking criteria

It is to be checked that the stresses σ_{1F} and τ_{1F} calculated according to [5.1.2] are in compliance with the following formulae:

$$\sigma_{1F} \le \sigma_{1,ALL}$$

$$\tau_{1F} \le \tau_{1,ALL}$$

where $\sigma_{1,ALL}$ and $\tau_{1,ALL}$ are the allowable normal and shear stresses defined in Pt B, Ch 6, Sec 2, [3.1] and Pt B, Ch 6, Sec 2, [3.2], respectively.

6 Hull scantlings

6.1 Plating

6.1.1 Minimum net thickness of side plating for single side skin bulk carriers

The net thickness of the side plating located between hopper and topside tanks is to be not less than the value obtained, in mm, from the following formula:

$$t_{MIN} = L^{0,5} - t_C$$

6.1.2 Buckling check for bulk carriers equal to or greater than 150 m in length *(1/4/2006)*

These requirements apply, in addition to those in Pt B, Ch 7, Sec 1, [5], to all bulk carriers equal to or greater than 150 m in length, intended for the carriage of bulk cargoes having dry bulk density of 1,0 t/m^3 or above.

For such ships, the buckling strength of plating contributing to the hull girder longitudinal strength is also to be checked in the flooded conditions specified in [4.4]. This check is to be carried out according to Pt B, Ch 7, Sec 1, [5.4.1] and Pt B, Ch 7, Sec 1, [5.4.2], where the compression stress is to be calculated according to the following formula:

$$\sigma_{X1,F} = \gamma_{S1}\sigma_{S1,F} + \gamma_{W1}\sigma_{WV1,F}$$

where:

γ_{S1}, γ_{W1} : Partial safety factors, defined in Pt B, Ch 7, Sec 1, [1.2] for buckling checks

$\sigma_{S1,F}$, $\sigma_{WV1,F}$: Hull girder normal stresses, in N/mm^2, defined in Tab 1.

Table 1 : Hull girder normal compression stresses in flooded conditions

Condition	$\sigma_{S1,F}$ in N/mm^2	$\sigma_{WV1,F}$ in N/mm^2
$z \ge N$	$\left\lvert \frac{M_{SW,FS}}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{0,5 M_{WV,S}}{I_Y}(z-N) \right\rvert 10^{-3}$
$z < N$	$\left\lvert \frac{M_{SW,FH}}{I_Y}(z-N) \right\rvert 10^{-3}$	$\left\lvert \frac{0,5 M_{WV,H}}{I_Y}(z-N) \right\rvert 10^{-3}$

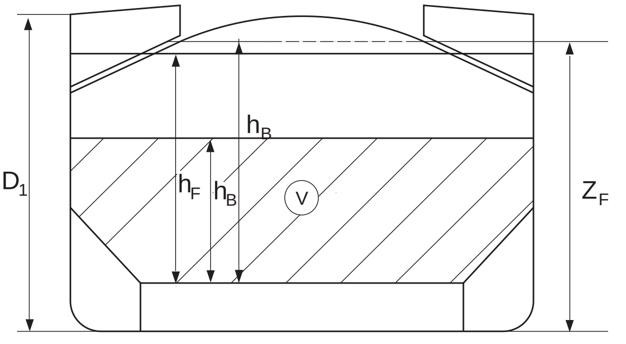
Note 1:
$M_{SW,FS}$, $M_{SW,FH}$: Still water bending moment, in kNm, in flooded conditions, in sagging and hogging conditions, respectively, at the hull transverse section under consideration, to be calculated according to [4.4]
$M_{WV,S}$, $M_{WV,H}$: Vertical wave bending moments, in kN.m, in sagging and hogging conditions, respectively, at the hull transverse section under consideration, defined in Pt B, Ch 5, Sec 2, [3.1].

Table 2 : Shear stresses induced by vertical shear forces *(1/4/2006)*

Ship typolog	Location	t, in mm	δ	Meaning of symbols used in the definition of δ
Single side skin bulk carrier	Sides	t_S	0,5	
Double side skin bulk carrier	Sides	t_S	$(1 - \phi) / 2$	$\phi = 0,275 + 0,25\alpha$ $\alpha = t_{ISM}/t_{SM}$
	Inner sides	t_{IS}	$\phi / 2$	

Note 1:
t_S, t_{IS} : Minimum thicknesses, in mm, of side, inner side plating, respectively
t_{SM}, t_{ISM} : Mean thicknesses, in mm, over all the strakes of side, inner side plating, respectively. They are calculated as $\Sigma(\ell_i t_i)/\Sigma\ell_i$, where ℓ_i and t_i are the length, in m, and the thickness, in mm, of the i^{th} strake of side, inner side.

Figure 14 : Double bottom - Flooding head and level height of the dry bulk cargo



V=Volume of cargo

6.2 Ordinary stiffeners

6.2.1 Minimum net thicknesses of side frames for single side skin bulk carriers

The net thicknesses of side frames and their brackets, in way of cargo holds, are to be not less than the values given in Tab 3.

6.2.2 Scantlings of side frames adjacent to the collision bulkhead

The net scantlings of side frames in way of the foremost cargo hold and immediately adjacent to the collision bulkhead are to be increased by 25% with respect to those determined according to Pt B, Ch 7, Sec 2 or Pt B, Ch 8, Sec 4, as applicable, in order to prevent excessive imposed deformation on the side shell plating.

As an alternative, supporting structures are to be fitted which maintain the continuity of fore peak girders within the foremost cargo hold.

6.2.3 Hopper and topside tank ordinary stiffeners

These requirements apply to the ordinary stiffeners of side and sloped longitudinal bulkheads, within hopper and topside tanks, which support the connecting brackets fitted in way of the side frame brackets, according to [3.2.7].

The scantlings of these ordinary stiffeners are to be determined according to Pt B, Ch 7, Sec 2 or Pt B, Ch 8, Sec 4, as applicable, with their span measured according to Pt B, Ch 4, Sec 3, [3.2] between hopper or topside tank primary supporting members.

Alternative arrangements may be considered by the Society on a case-by-case basis. In these cases, the scantlings of the above ordinary stiffeners are to be determined for the purpose of effectively supporting the connecting brackets.

6.2.4 Buckling check for bulk carriers equal to or greater than 150 m in length *(1/4/2006)*

These requirements apply, in addition to those in Pt B, Ch 7, Sec 2, [4], to all bulk carriers equal to or greater than 150 m in length, intended for the carriage of bulk cargoes having dry bulk density of 1,0 t/m³ or above.

For such ships, the buckling strength of ordinary stiffeners contributing to the hull girder longitudinal strength is also to be checked in the flooded conditions specified in [4.4]. This check is to be carried out according to Pt B, Ch 7, Sec 2, [4.4.1], where the compression stress is to be calculated according to the following formula:

$$\sigma_{X1,F} = \gamma_{S1}\sigma_{S1,F} + \gamma_{W1}\sigma_{WV1,F}$$

where:

γ_{S1}, γ_{W1} : Partial safety factors, defined in Pt B, Ch 7, Sec 2, [1.2] for buckling checks

$\sigma_{S1,F}$, $\sigma_{WV1,F}$: Hull girder normal stresses, in N/mm², defined in Tab 1.

Table 3 : Minimum net thicknesses of side frames

Item	Minimum net thickness, in mm
Side frame webs	C_L (7,0 + 0,03L_1) - t_C
Lower end bracket	The greater of: • C_L (7,0 + 0,03L_1) + 2 - t_C • as fitted net thickness of side frame web
Upper end bracket	The greater of: • C_L (7,0 + 0,03L_1) - t_C • as fitted net thickness of side frame web
Note 1: C_L : Coefficient equal to: • 1,15 for side frames in way of the foremost cargo hold • 1,0 for side frames in way of other cargo holds L_1 : Ship's length, in m, defined in Pt B, Ch 1, Sec 2, [2].	

7 Scantlings of transverse vertically corrugated watertight bulkheads and double bottom of bulk carriers equal to or greater than 150 m in length

7.1 Evaluation of scantlings of transverse vertically corrugated watertight bulkheads in flooding conditions

7.1.1 Application *(1/7/2014)*

These requirements apply to the transverse vertically corrugated watertight bulkheads of bulk carriers which are bounded by at least one cargo hold that is to be considered individually flooded according to the requirements in [4.6.1] and which are of 150 m in length and upwards, intending to carry solid bulk cargoes having a density of 1,0 t/m³ or above, and with:

a) Single side skin construction, or

b) Double side skin construction in which any part of the longitudinal bulkhead is located within B/5 or 11,5 m, whichever is less, inboard from the ship's side at right angles to the centreline at the assigned summer load line.

7.1.2 Plating

The bulkhead local net plate thickness t, in mm, is to be not less than that obtained from the following formula:

$$t = 14{,}9 s_W \sqrt{\frac{1{,}05p}{R_{eH}}}$$

where:

p : Resultant pressure, in kN/m², as defined in [4.6.8]

s_W : Plate width, in m, to be taken equal to the width of the corrugation flange or web, whichever is the greater (see Fig 5).

For built-up corrugation bulkheads, when the thicknesses of the flange and web are different:

- the net thickness of the narrower plating is to be not less than that obtained, in mm, from the following formula:

$$t_N = 14{,}9 s_N \sqrt{\frac{1{,}05p}{R_{eH}}}$$

- the net thickness of the wider plating is not to be less than the greater of those obtained, in mm, from the following formulae:

$$t_W = 14{,}9 s_W \sqrt{\frac{1{,}05p}{R_{eH}}}$$

$$t_W = \sqrt{\frac{462 s_W^2 p}{R_{eH}} - t_{NP}^2}$$

where:

t_{NP} : Actual net thickness of the narrower plating, in mm, to be not taken greater than:

$$t_{NP} = 14{,}9 s_W \sqrt{\frac{1{,}05p}{R_{eH}}}$$

7.1.3 Bending capacity of corrugations

The bending capacity of the corrugations is to comply with the following formula:

$$10^3 \frac{M}{(0{,}5W_{LE} + W_M)R_{eH}} \le 0{,}95$$

where :

M : Bending moment in a corrugation, to be calculated according to [4.6.9]

F : Resultant force, in kN, to be calculated according to [4.6.8]

W_{LE} : Net section modulus, in cm³, of one half pitch corrugation, to be calculated at the lower end of the corrugations according to [3.5.9], without being taken greater than the value obtained from the following formula:

$$W_{LE,M} = W_G + 10^3\left(\frac{Q h_G - 0{,}5 h_G^2 s_C p_G}{R_{eH}}\right)$$

W_G : Net section modulus, in cm³, of one half pitch corrugation, to be calculated in way of the upper end of shedder or gusset plates, as applicable, according to [3.5.10]

Q : Shear force in a corrugation, to be calculated according to [4.6.9]

h_G : Height, in m, of shedders or gusset plates, as applicable (see Fig 8 to Fig 12)

p_G : Resultant pressure, in kN/m², to be calculated in way of the middle of the shedders or gusset plates, as applicable, according to [4.6.8]

W_M : Net section modulus, in cm³, of one half pitch corrugation, to be calculated at the mid-span of corrugations according to [3.5.10], without being taken greater than $1{,}15W_{LE}$.

7.1.4 Shear yielding check of the bulkhead corrugations

The shear stress τ, calculated according to [4.6.9], is to comply with the following formula:

$$\tau \le \frac{R_{eH}}{2}$$

7.1.5 Shear buckling check of the bulkhead corrugation webs

The shear stress τ, calculated according to [4.6.9], is to comply with the following formula:

$$\tau \le \tau_C$$

where:

τ_C : Critical shear buckling stress to be obtained, in N/mm², from the following formulae:

$$\tau_c = \tau_E \quad \text{for} \quad \tau_E \le \frac{R_{eH}}{2\sqrt{3}}$$

$$\tau_c = \frac{R_{eH}}{\sqrt{3}}\left(1 - \frac{R_{eH}}{4\sqrt{3}\tau_E}\right) \quad \text{for} \quad \tau_E > \frac{R_{eH}}{2\sqrt{3}}$$

τ_E : Euler shear buckling stress to be obtained, in N/mm², from the following formula:

$$\tau_E = 0{,}9 k_t E\left(\frac{t_W}{10^3 C}\right)^2$$

k_t : Coefficient to be taken equal to 6,34

t_W : Net thickness, in mm, of the corrugation webs

C : width, in m of the corrugation webs (see Fig 5).

7.1.6 Lower and upper stool side plating and ordinary stiffeners

When lower or upper stools are fitted, according to [3.5.3] and [3.5.4] respectively, the net thickness of their side plating and the section modulus of their ordinary stiffeners are to be not less than those required in Pt B, Ch 7, Sec 1, [3.5] and Pt B, Ch 7, Sec 2, [3.8] for flooding conditions, considering the load model in [4.6].

7.2 Evaluation of double bottom capacity and allowable hold loading in flooding conditions

7.2.1 Application *(1/7/2014)*

These requirements apply to the double bottoms of bulk carriers which belong to cargo holds that are to be considered individually flooded according to the requirements in [4.7.1] and which are of 150 m in length and upwards, intending to carry solid bulk cargoes having a density of 1,0 t/m³ or above, and with:

a) Single side skin construction or

b) Double side skin construction in which any part of the longitudinal bulkhead is located within B/5 or 11,5 m, whichever is less, inboard from the ship's side at right angles to the centreline at the assigned summer load line.

7.2.2 Shear capacity of the double bottom

The shear capacity of the double bottom is to be calculated as the sum of the shear strength at each end of:

- all floors adjacent to both hopper tanks, less one half of the shear strength of the two floors adjacent to each stool, or transverse bulkhead if no stool is fitted (see Fig 15); the floor shear strength is to be calculated according to [7.2.4]
- all double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted; the girder shear strength is to be calculated according to [7.2.5].

Where in the end holds, girders or floors run out and are not directly attached to the boundary stool or hopper tank girder, their strength is to be evaluated for the one end only.

The floors and girders to be considered in calculating the shear capacity of the double bottom are those inside the hold boundaries formed by the hopper tanks and stools (or transverse bulkheads if no stool is fitted). The hopper tank side girders and the floors directly below the connection of the stools (or transverse bulkheads if no stool is fitted) to the inner bottom may not be included.

When the geometry and/or the structural arrangement of the double bottom is/are such as to make the above assumptions inadequate, the shear capacity of the double bottom is to be calculated by means of direct calculations to be carried out according to Pt B, Ch 7, App 1, as far as applicable.

7.2.3 Net thicknesses

The floor and girder shear strength is to be calculated using the net thickness of floor and girder webs, to be obtained, in mm, from the following formula:

$$t_N = t - 2,5$$

where:

t : actual gross thickness, in mm, of floor and girder webs.

7.2.4 Floor shear strength

The floor shear strength, in kN, is to be obtained from the following formulae:

- in way of the floor panel adjacent to the hopper tank:

$$S_{F1} = A_F \frac{\tau_A}{\eta_1} 10^{-3}$$

- in way of the openings in the outermost bay (i.e. that bay which is closer to the hopper tank):

$$S_{F2} = A_{F,H} \frac{\tau_A}{\eta_2} 10^{-3}$$

where:

A_F : Net sectional area, in mm², of the floor panel adjacent to the hopper tank

$A_{F,H}$: Net sectional area, in mm², of the floor panels in way of the openings in the outermost bay (i.e. that bay which is closer to the hopper tank)

τ_A : Allowable shear stress, in N/mm², equal to the lesser of:

$$\tau_A = 0,645 \frac{R_{eH}^{0,6}}{(s/t_N)^{0,8}} \quad \text{and} \quad \tau_A = \frac{R_{eH}}{\sqrt{3}}$$

t_N : Floor web net thickness, in mm, defined in [7.2.3]

s : Spacing, in m, of stiffening members of the panel considered

η_1 : Coefficient to be taken equal to 1,1

η_2 : Coefficient generally to be taken equal to 1,2; it may be reduced to 1,1 where appropriate reinforcements are fitted in way of the openings in the outermost bay, to be examined by the Society on a case-by-case basis.

7.2.5 Girder shear strength

The girder shear strength, in kN, is to be obtained from the following formulae:

- in way of the girder panel adjacent to the stool (or transverse bulkhead, if no stool is fitted):

$$S_{G1} = A_G \frac{\tau_A}{\eta_1} 10^{-3}$$

- in way of the largest opening in the outermost bay (i.e. that bay which is closer to the stool, or transverse bulkhead, if no stool is fitted):

$$S_{G2} = A_{G,H} \frac{\tau_A}{\eta_2} 10^{-3}$$

A_G : Sectional area, in mm², of the girder panel adjacent to the stool (or transverse bulkhead, if no stool is fitted)

$A_{G,H}$: Net sectional area, in mm², of the girder panel in way of the largest opening in the outermost bay (i.e. that bay which is closer to the stool, or transverse bulkhead, if no stool is fitted)

τ_A : Allowable shear stress, in N/mm², defined in [7.2.4], where t_N is the girder web net thickness

η_1 : Coefficient to be taken equal to 1,1

η_2 : Coefficient generally to be taken equal to 1,15; it may be reduced to 1,1 where appropriate reinforcements are fitted in way of the largest opening in the outermost bay, to be examined by the Society on a case-by-case basis.

7.2.6 Allowable hold loading

The allowable hold loading is to be obtained, in t, from the following formula:

$$W = \rho_B V \frac{1}{F}$$

where:

F : Coefficient to be taken equal to:

- F = 1,1 in general
- F = 1,05 for steel mill products

V : Volume, in m³, occupied by cargo at a level h_B (see Fig 14)

h_B : Level of cargo, in m, to be obtained from the following formula:

$$h_B = \frac{X}{\rho_B g}$$

X : Pressure, in kN/m², to be obtained from the following formulae:

- for dry bulk cargoes, the lesser of:

$$X = \frac{Z + \rho g(z_F - 0{,}1D_1 - h_F)}{1 + \frac{\rho}{\rho_B}(perm - 1)}$$

$$X = Z + \rho g(z_F - 0{,}1D_1 - h_F perm)$$

- for steel mill products:

$$X = \frac{Z + \rho g(z_F - 0{,}1D_1 - h_F)}{1 - \frac{\rho}{\rho_B}}$$

perm : Permeability of cargo, which need not be taken greater than 0,3

Z : Pressure, in kN/m², to be taken as the lesser of:

$$Z = \frac{C_H}{A_{DB,H}}$$

$$Z = \frac{C_E}{A_{DB,E}}$$

C_H : Shear capacity of the double bottom, in kN, to be calculated according to [7.2.2], considering, for each floor, the lesser of the shear strengths S_{F1} and S_{F2} (see [7.2.4]) and, for each girder, the lesser of the shear strengths S_{G1} and S_{G2} (see [7.2.5])

C_E : Shear capacity of the double bottom, in kN, to be calculated according to [7.2.2], considering, for each floor, the shear strength S_{F1} (see [7.2.4]) and, for each girder, the lesser of the shear strengths S_{G1} and S_{G2} (see [7.2.5])

$$A_{DB,H} = \sum_{i=1}^{n} S_i B_{DB,i}$$

$$A_{DB,E} = \sum_{i=1}^{n} S_i (B_{DB} - s)$$

n : Number of floors between stools (or transverse bulkheads, if no stool is fitted)

S_i : Space of ith-floor, in m

$B_{DB,i}$: Length, in m, to be taken equal to :

- $B_{DB,i} = B_{DB} - s$ for floors for which $S_{F1} < S_{F2}$ (see [7.2.4])
- $B_{DB,i} = B_{DB,h}$ for floors for which $S_{F1} \geq S_{F2}$ (see [7.2.4])

B_{DB} : Breadth, in m, of double bottom between the hopper tanks (see Fig 16)

$B_{DB,h}$: Distance, in m, between the two openings considered (see Fig 16)

s : Spacing, in m, of inner bottom longitudinal ordinary stiffeners adjacent to the hopper tanks.

8 Fore part

8.1 Reinforcement of the flat bottom forward area

8.1.1 Minimum forward draught *(1/7/2003)*

The structures of the bottom forward are to be strengthened in accordance with the requirements in Pt B, Ch 9, Sec 1, [3] against dynamic pressures due to bottom impact for the condition specified in [4.3.2] at the minimum forward draught.

9 Hatch covers, hatch coamings and closing devices

9.1 Application

9.1.1 *(1/7/2024)*

Refer to the requirements for Type 2 ships in Pt B, Ch 9, Sec 7.

10 Hull outfitting

10.1 Forecastle

10.1.1 General *(1/1/2004)*

Ships with service notation **bulk carrier ESP** are to be fitted with an enclosed forecastle on the freeboard deck.

The required dimensions of the forecastle are defined in [10.1.2].

The structural arrangements and scantlings of the forecastle are to comply with the requirements in Pt B, Ch 10, Sec 2.

10.1.2 Dimensions *(1/1/2004)*

The forecastle is to be located on the freeboard deck with its aft bulkhead fitted in way or aft of the forward bulkhead of the foremost hold, as shown in Fig 17.

The forecastle height H_F above the main deck is to be not less than the greater of:

- the standard height of a superstructure, as specified in Pt B, Ch 1, Sec 2, Tab 2, or
- H_C + 0,5 m, where H_C is the height of the forward transverse hatch coaming of cargo hold No.1,

$$l_F \le 5\sqrt{H_F - H_C}$$

All points of the aft edge of the forecastle deck are to be located at a distance from the hatch coaming plate in order to apply the reduced loading to the No.1 forward transverse hatch coaming and No.1 hatch cover in applying Pt B, Ch 9, Sec 7, [3.3.2] and Pt B, Ch 9, Sec 7, [7.2.3], respectively.

A breakwater may not be fitted on the forecastle deck with the purpose of protecting the hatch coaming or hatch covers. If fitted for other purposes, it is to be located such that its upper edge at centreline is not less than H_B / tan20° forward of the aft edge of the forecastle deck, where H_B is the height of the breakwater above the forecastle (see Fig 17).

Figure 15 : Double bottom structure

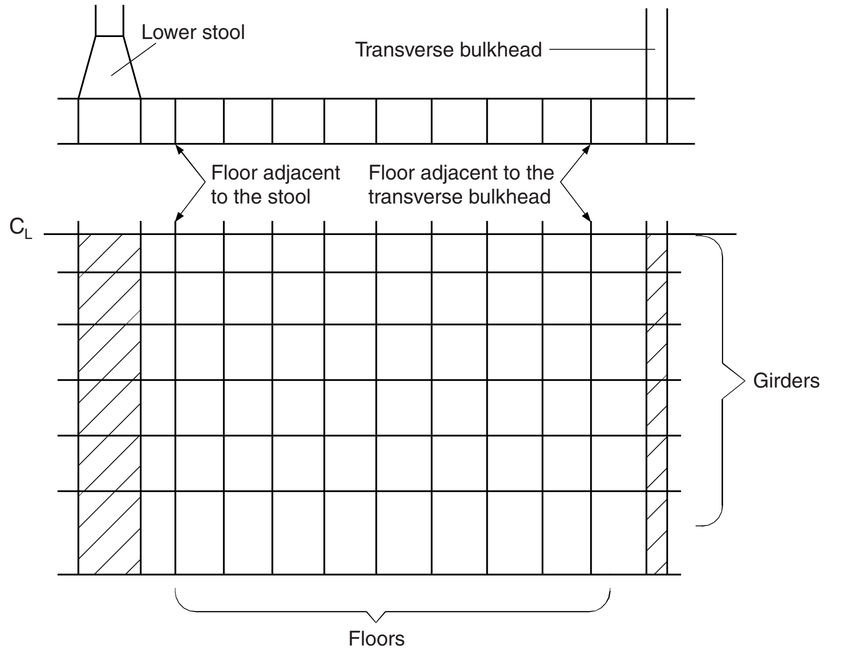


Figure 16 : Dimensions B_{DB} and $B_{DB,h}$

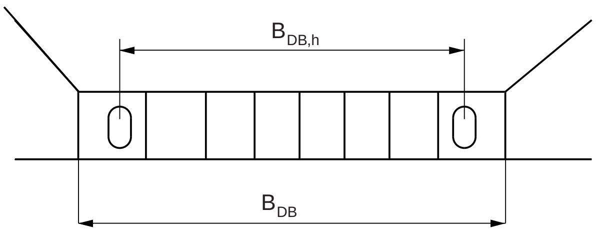
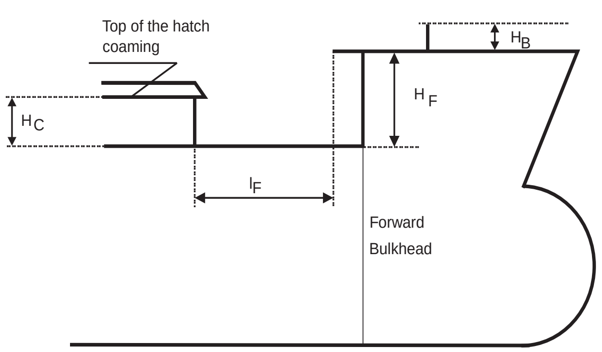


Figure 17 : Forecastle arrangement *(1/1/2004)*



11 Protection of hull metallic structures

11.1 Protection of sea water ballast tanks

11.1.1 *All dedicated seawater ballast tanks are to have an efficient corrosion prevention system, such as hard protective coatings or equivalent.*

The coatings are preferably to be of a light colour, i.e. a colour easily distinguishable from rust which facilitates inspection.

Where appropriate, sacrificial anodes may also be used.

11.2 Protection of cargo holds

11.2.1 Coating

It is the responsibility of the shipbuilder and of the Owner to choose coatings suitable for the intended cargoes, in particular for the compatibility with the cargo, and to see that they are applied in accordance with the Manufacturer's requirements.

11.2.2 Application

All internal and external surfaces of hatch coamings and hatch covers and all internal surfaces of cargo holds (side and transverse bulkheads) are to have an efficient protective coating, of an epoxy type or equivalent, applied in accordance with the Manufacturer's recommendations.

The side (single and double skin) and transverse bulkhead areas to be coated are specified in [11.2.3] to [11.2.5].

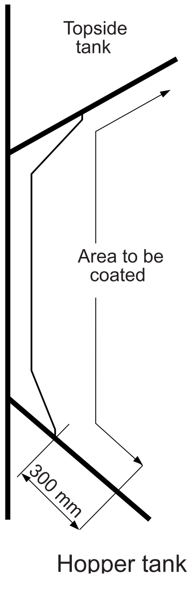
11.2.3 Single side areas to be coated

The areas to be coated are:

- the internal surfaces of the side plating
- the side frames with end brackets
- the internal surfaces of the topside tank sloping plates and, for a distance of 300 mm below, of the hopper tank sloping plates.

These areas are shown in Fig 18.

Figure 18 : Single side - Areas to be coated



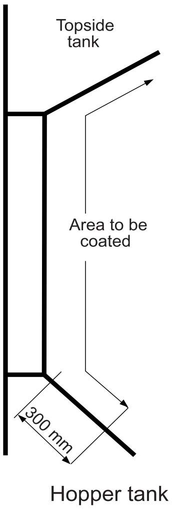
11.2.4 Double side areas to be coated

The areas to be coated are the internal surfaces of:

- the inner side plating
- the internal surfaces of the topside tank sloping plates and the hopper tank sloping plates for a distance of 300 mm below their upper ends.

These areas are shown in Fig 19.

Figure 19 : Double side - Areas to be coated



11.2.5 Transverse bulkhead areas to be coated

The areas to be coated are the upper parts down to 300 mm below the top of the lower stool. Where there is no lower stool, the area to be coated is the whole transverse bulkhead. These areas are shown in Fig 20.

12 Construction and testing

12.1 Welding and weld connections

12.1.1 The welding factors for some hull structural connections are specified in Tab 4. These welding factors are to be used, in lieu of the corresponding factors specified in Pt B, Ch 12, Sec 1, Tab 2, to calculate the throat thickness of fillet weld T connections according to Pt B, Ch 12, Sec 1, [2.3]. For the connections in Tab 4, continuous fillet welding is to be adopted.

12.2 Special structural details

12.2.1 The specific requirements in Pt B, Ch 12, Sec 2, [2.5] for ships with the service notation **bulk carrier ESP** are to be complied with.

Figure 20 : Transverse bulkheads - Areas to be coated

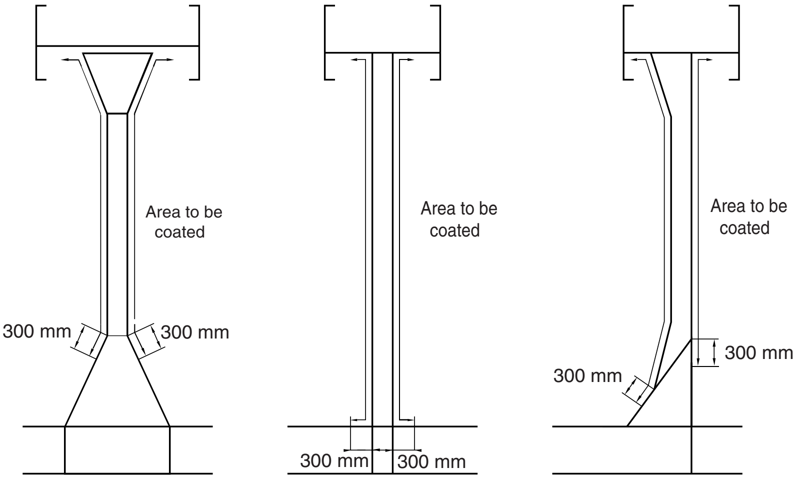


Figure 21 : Zones “a” and “b” of weld connections of side frames

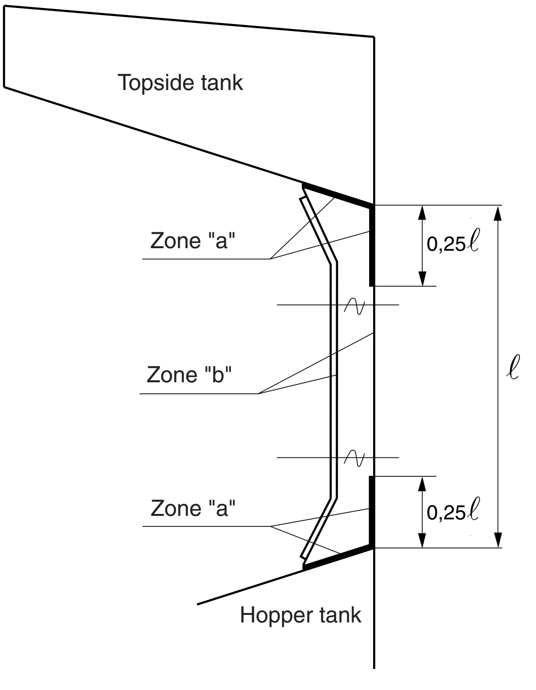


Table 4 : Welding factor w_F *(1/7/2002)*

Hull area	Connection			Welding factor w_F
	of	to		
Double bottom in way of cargo holds	girders	bottom and inner bottom plating		0,35
		floors (interrupted girders)		0,35
	floors	bottom and inner bottom plating		0,35
		inner bottom in way of bulkheads or their lower stools, in general		0,45
		inner bottom in way of corrugated watertight bulkheads or their lower stools		Full penetration or partial penetration welding
		girders (interrupted floors)		0,35
Bulkheads	structures of tank and watertight bulkheads	lower stool top plate or, if no lower stool is fitted, inner bottom and hopper tank sloping plates	plating and ordinary stiffeners (plane bulkheads)	0,45
			vertical corrugations (corrugated bulkheads)	Full penetration welding
		upper stool bottom plate or, if no upper stool is fitted, deck structures and topside tank sloping plates		0,45
		side structures		0,35
	lower stool structures	boundaries	plating of lower stools, in general	0,45
			plating of lower stools supporting corrugated watertight bulkheads	Full penetration or partial penetration welding
			ordinary stiffeners and diaphragms	0,45
	upper stool structures	boundaries		0,45
	effective shedder plates (see [3.5.7])	vertical corrugations and lower stool top plate		One side penetration welding or equivalent
	effective gusset plates (see [3.5.8])	lower stool top plate		Full penetration welding
		vertical corrugations and shedder plates		One side penetration welding or equivalent
Side	web of side frames and brackets	side plating, hopper and topside tank sloping plates, face plates	in zone “a” **(1)**	0,45 **(2)**
			in zone “b” **(1)**	0,40 **(2)**

(1) Zones “a” and “b” are defined in Fig 21.
(2) Where the hull form is such as to prohibit an effective fillet weld, the Society may require edge preparation of the web of side frame and bracket to be carried out in order to ensure the same efficiency as the required weld connections.

SECTION 4 MACHINERY

1 Draining and pumping forward spaces

1.1 Application

1.1.1 *(1/1/2005)*

This requirement applies to bulk carriers which are to comply with Regulation 13 of Chapter XII of SOLAS Convention.

1.2 Dewatering capacity

1.2.1 *(1/1/2005)*

The dewatering system for ballast tanks located forward of the collision bulkhead and for bilges of dry spaces any part of which extends forward of the foremost cargo hold is to be designed to remove water from the forward spaces at a rate of not less than 320A m^3/h, where A is the cross-sectional area in m^2 of the largest air pipe or ventilator pipe connected from the exposed deck to a closed forward space that is required to be dewatered by these arrangements.

APPENDIX 1 INTACT STABILITY CRITERIA FOR GRAIN LOADING

1 Calculation of assumed heeling moments due to cargo shifting

1.1 Stowage of bulk grain

1.1.1 General

All necessary and reasonable trimming is to be performed to level all free grain surfaces and to minimise the effect of grain shifting.

1.1.2 Filled compartment trimmed

In any filled compartment trimmed, as defined in Sec 3, [2.1.2], the bulk grain is to be trimmed so as to fill all spaces under the decks and hatch covers to the maximum extent possible.

1.1.3 Filled compartment untrimmed

In any filled compartment untrimmed, as defined in Sec 3, [2.1.3], the bulk grain is to be filled to the maximum extent possible in way of the hatch opening but may be at its natural angle of repose outside the periphery of the hatch opening. A filled compartment may qualify for this classification if it falls into one of the following categories:

a) *the Society may, under [1.7], grant dispensation from trimming in those cases where the underdeck void geometry resulting from free flowing grain in a compartment, which may be provided with feeder ducts, perforated decks or other similar means, is taken into account when calculating the void depths, or*

b) *the compartment is "specially suitable" as defined in Sec 3, [2.1.6], in which case dispensation may be granted from trimming the ends of that compartment.*

1.1.4 Grain in partially filled compartments

If there is no bulk grain or other cargo above a lower cargo space containing grain, the hatch covers are to be secured in an approved manner having regard to the mass and permanent arrangements provided for securing such covers.

When bulk grain is stowed on top of closed 'tweendeck hatch covers which are not grain-tight, such covers are to be made grain-tight by taping the joints, covering the entire hatchway with tarpaulins or separation cloths, or other suitable means.

After loading, all free grain surfaces in partly filled compartments are to be level.

1.1.5 Cargo securing

Unless account is taken of the adverse heeling effect due to the grain shift according to these Rules, the surface of the bulk grain in any partly filled compartment is to be secured so as to prevent a grain shift by overstowing as described in [1.9.1] to [1.9.3]. Alternatively, in partly filled compartments, the bulk grain surface may be secured by strapping or lashing as described in [1.9.4] or [1.9.5].

Lower cargo spaces and 'tweendeck spaces in way thereof may be loaded as one compartment provided that, in calculating transverse heeling moments, proper account is taken of the flow of grain into the lower spaces.

1.1.6 Longitudinal division

In filled compartments trimmed, filled compartments untrimmed and partly filled compartments, longitudinal divisions may be installed as a device to reduce the adverse heeling effect of grain shift provided that:

a) *the division is grain-tight,*

b) *the construction meets the requirements in Part B for longitudinal bulkheads; if no particular requirement is foreseen see MSC Res. 23(59)sect 11-14); and*

c) *in 'tweendecks, if fitted, the division extends from deck to deck and in other cargo spaces the division extends downwards from the underside of the deck or hatch covers, as described in [1.3.2] a)* (second bullet), *Note 2, [1.3.2] b), Note 7, or [1.6.1] b), as applicable.*

1.2 General assumptions

1.2.1 Voids in spaces loaded with grain

For the purpose of calculating the adverse heeling moment due to a shift of cargo surface in ships carrying bulk grain it is to be assumed that:

a) *in filled compartments which have been trimmed in accordance with [1.1.2], a void exists under all boundary surfaces having an inclination to the horizontal less than 30° and that void is parallel to the boundary surface having an average depth calculated according to the formula:*

$$V_d = V_{d1} + 0,75(d - 600)$$

where:

V_d : *Average void depth, in mm*

V_{d1} : *Standard void depth, in mm, from Tab 1*

d : *Actual girder depth, in mm.*

In any case, V_d is to be assumed equal to or greater than 100 mm.

b) *within filled hatchways and in addition to any open void within the hatch cover there is a void of average depth of 150 mm measured down to the grain surface from the lowest part of the hatch cover or the top of the hatch side coaming, whichever is the lower.*

c) *in a filled compartment untrimmed which is exempted from trimming outside the periphery of the hatchway by the provisions of [1.1.3] a), it is to be assumed that the surface of the grain after loading will slope into the void* *space underdeck, in all directions, at an angle of 30° to the horizontal from the edge of the opening which establishes the void.*

d) *In a filled compartment untrimmed which is exempted from trimming in the ends of the compartment under the provisions of [1.1.3] b) , it is to be assumed that the surface of the grain after loading will slope in all directions away from the filling area at an angle of 30° from the lower edge of the hatch end beam. However, if feeding holes are provided in the hatch end beams in accordance with Tab 2, then the surface of the grain after loading is to be assumed to slope in all directions, at an angle of 30° from a line on the hatch end beam which is the mean of the peaks and valleys of the actual grain surface as shown in Fig 1.*

The description of the pattern of grain surface behaviour to be assumed in partly filled compartments is contained in [1.6].

1.2.2 Assumptions in filled compartments trimmed

For the purpose of demonstrating compliance with the stability criteria specified in Sec 3, [2.2.3], the ship's stability calculations are normally to be based upon the assumption that the centre of gravity of cargo in a filled compartment trimmed is at the volumetric centre of the whole cargo space. In those cases where the Society authorises account to be taken of the effect of assumed underdeck voids on the vertical position of the centre of gravity of the cargo in filled compartments trimmed, it is necessary to compensate for the adverse effect of the vertical shift of grain surfaces by increasing the assumed heeling moment due to the transverse shift of grain as follows:

$$M_{H,T} = 1{,}06\, M_{H,C}$$

where:

$M_{H,T}$: *Total heeling moment, in t.m*

$M_{H,C}$: *Calculated transverse heeling moment, in t.m*

In all cases the weight of cargo in a filled compartment trimmed is to be the volume of the whole cargo space divided by the stowage factor.

1.2.3 Assumptions in filled compartments untrimmed

The centre of gravity of cargo in a filled compartment untrimmed is to be taken to be the volumetric centre of the whole cargo compartment with no account being allowed for voids. In all cases the weight of cargo is to be the volume of the cargo (resulting from the assumptions stated in [1.2.1] c) or [1.2.1] d)) divided by the stowage factor.

1.2.4 Assumptions in partially filled compartments

In partly filled compartments the adverse effect of the vertical shift of grain surfaces is to be taken into account as follows:

$$M_{H,T} = 1{,}12\, M_{H,C}$$

where $M_{H,T}$ and $M_{H,C}$ are defined in [1.2.2].

1.2.5 Equivalent methods

Any other equally effective method may be adopted to make the compensation required in [1.2.2] and [1.2.4].

Table 1 : Standard void depth

Distance, in m, from hatch end or hatch side to boundary of compartment	Standard void depth V_{d1} in mm
0,5	570
1,0	530
1,5	500
2,0	480
2,5	450
3,0	440
3,5	430
4,0	430
4,5	430
5,0	430
5,5	450
6,0	470
6,5	490
7,0	520
7,5	550
8,0	590

Note 1:
For boundary distances greater than 8,0 m, the standard void depth V_{d1} is to be linearly extrapolated with 80 mm increases for each 1,0 m increase in length.

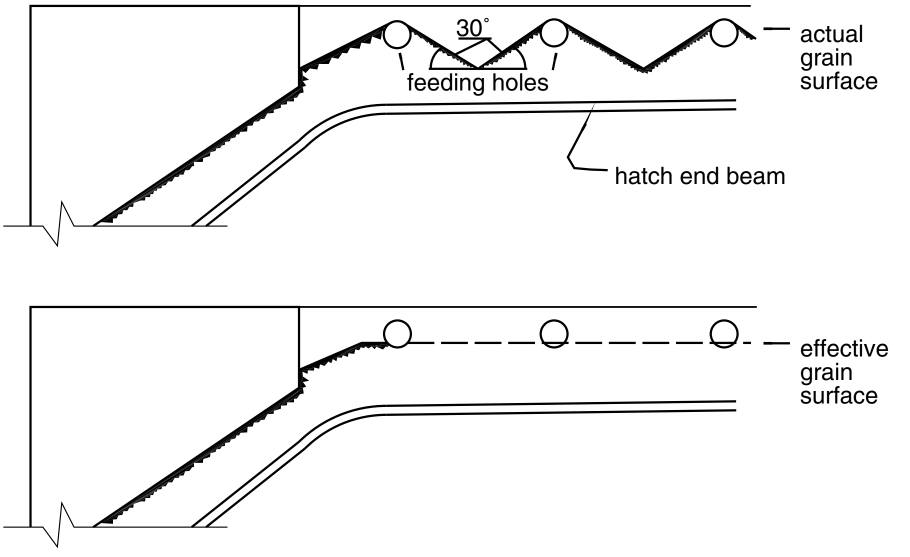
Note 2:
In the corner area of a compartment, the boundary distance is to be the perpendicular distance from the line of the hatch side girder or the line of the hatch end beam to the boundary of the compartment, whichever is the greater. The girder depth d is to be taken as the depth of the hatch side girder or the hatch end beam, whichever is the lesser.

Note 3:
Where there is a raised deck clear of the hatchway, the average void depth measured from the underside of the raised deck is to be calculated using the standard void depth in association with a girder depth of the hatch end beam plus the height of the raised deck.

Table 2 : Requirements for feeding holes

Minimum diameter, in mm	Area, in cm^2	Maximum spacing, in m
90	63,6	0,60
100	78,5	0,75
110	95,0	0,90
120	113,1	1,07
130	133,0	1,25
140	154,0	1,45
150	177,0	1,67
160	201,0	1,90
170 or above	227,0	2,00

Figure 1 : Effective grain surface to be assumed



1.3 Assumed volumetric heeling moment of a filled compartment trimmed

1.3.1 General

The pattern of grain surface movement relates to a transverse section across the portion of the compartment being considered and the resultant heeling moment is to be multiplied by the length to obtain the total moment for that portion.

The assumed transverse heeling moment due to grain shifting is a consequence of final changes of shape and position of voids after grain has moved from the high side to the low side.

The resulting grain surface after shifting is to be assumed to be at 15° to the horizontal.

In calculating the maximum void area that can be formed against a longitudinal structural member, the effects of any horizontal surfaces, e.g. flanges or face bars, are to be ignored.

The total areas of the initial and final voids are to be equal.

Longitudinal structural members which are grain-tight may be considered effective over their full depth except where they are provided as a device to reduce the adverse effect of grain shift, in which case the provisions of [1.1.6] are to apply.

A discontinuous longitudinal division may be considered effective over its full length.

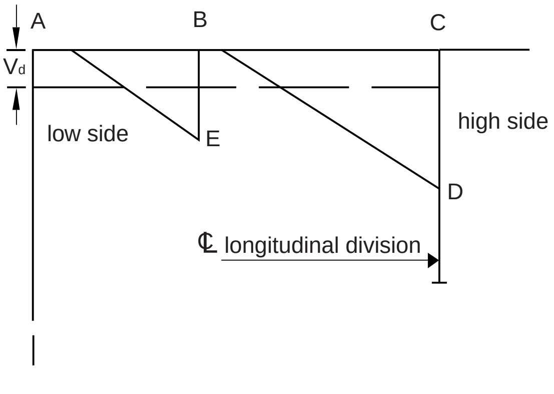
1.3.2 Assumptions

In the following paragraphs it is assumed that the total heeling moment for a compartment is obtained by adding the results of separate consideration of the following portions:

a) *before and abaft hatchways:*
   - *if a compartment has two or more main hatchways through which loading may take place, the depth of the underdeck void for the portion or portions between such hatchways is to be determined using the fore and aft distance to the mid-point between the hatchways*
   - *after the assumed shift of grain the final void pattern is to be as shown in Fig 2.*

b) *In and abreast of hatchways without longitudinal division, after the assumed shift of grain the final void pattern is to be as shown in Fig 3 or Fig 4.*

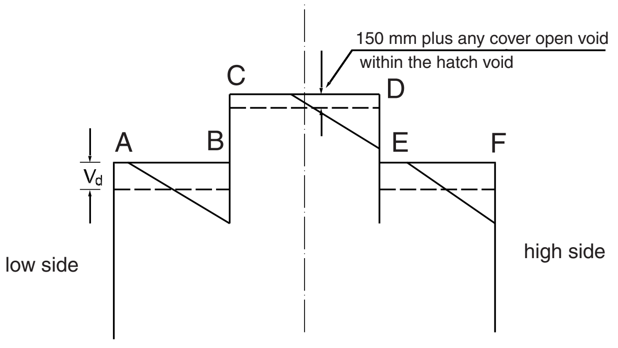
Figure 2 : Final void pattern



Note 1: If the maximum void area which can be formed against the girder at B is less than the initial area of the void under AB, i.e. AB.V_d the excess area is to be assumed to transfer to the final void on the high side.

Note 2: If, for example, the longitudinal division at C is one which has been provided in accordance with [1.1.6], it is to extend to at least 0,6 m below D or E, whichever gives the greater depth.

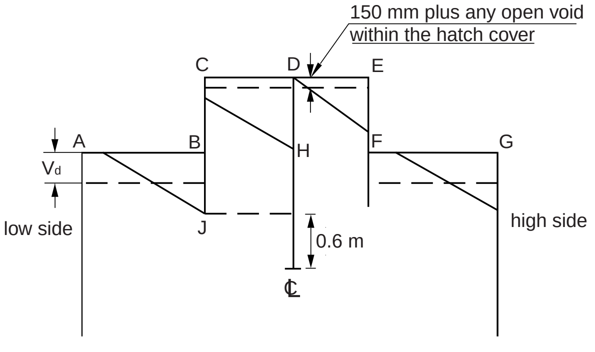
Figure 3 : Final void pattern



Note 3: AB: Any area in excess of that which can be formed against the girder at B is to transfer to the final void area in the hatchway.

Note 4: CD: Any area in excess of that which can be formed against the girder at E is to transfer to the final void area on the high side.

Figure 4 : Final void pattern



Note 5: The excess void area from AB is to transfer to the low side half of the hatchway in which two separate final void areas are formed: one against the centreline division and the other against the hatch side coaming and girder on the high side.

Note 6: If a bagged saucer or bulk bundle is formed in a hatchway it is to be assumed for the purpose of calculating the transverse heeling moment that such a device is at least equivalent to the centreline division.

Note 7: If the centreline division is one which has been provided in accordance with [1.1.6], it is to extend to at least 0,6 m below H or J, whichever gives the greater depth.

1.3.3 Compartment loaded in combination

The following paragraphs describe the patterns of void behaviour which are to be assumed when compartments are loaded in combination:

a) without effective centreline divisions:

- *under the upper deck:*

  as for the single deck arrangement described in [1.3.2] a) (second bullet) and [1.3.2] b)

- *under the second deck (if applicable):*

  the area of void available for transfer from the low side, i.e. original void area less area against the hatch side girder, is to be assumed to transfer as follows: one half to the upper deck hatchway and one quarter each to the high side under the upper and second deck

- *under the third and lower decks (if applicable):*

  the void areas available for transfer from the low side of each of these decks are to be assumed to transfer in equal quantities to all the voids under the decks on the high side and the void in the upper deck hatchway

b) with effective centreline divisions which extend into the upper deck hatchway:

- *at all deck levels abreast of the division the void areas available for transfer from the low side are to be assumed to transfer to the void under the low side half of the upper deck hatchway*
- *at the deck level immediately below the bottom of the division the void area available for transfer from the low side is to be assumed to transfer as follows: one half to the void under the low side half of the upper deck hatchway and the remainder in equal quantities to the voids under the decks on the high side*
- *at deck levels lower than those described above, the void area available for transfer from the low side of each of those decks is to be assumed to transfer in equal quantities to the voids in each of the two halves of the upper deck hatchway on each side of the division and the voids under the decks on the high side.*

c) with effective centreline divisions which do not extend into the upper deck hatchway:

Since no horizontal transfer of voids may be assumed to take place at the same deck level as the division, the void area available for transfer from the low side at this level is to be assumed to transfer above the division to voids on the high side in accordance with the principles of a) and b).

1.4 Assumed volumetric heeling moment of a filled compartment untrimmed

1.4.1 General

All the provisions for filled compartments trimmed set forth in [1.3] are to also apply to filled compartments untrimmed, except as reported in [1.4.2].

1.4.2 Additional requirements

In filled compartments untrimmed which are exempted from trimming outside the periphery of the hatchway under the provisions of [1.1.3] a), the following assumptions apply:

a) The resulting grain surface after shifting is to be assumed to be at an angle of 25° to the horizontal. However, if in any section of the compartment, forward, aft, or abreast of the hatchway the mean transverse area of the void in that section is equal to or less than the area which would be obtained by application of [1.2.1] a), then the angle of grain surface after shifting in that section is to be assumed to be 15° to the horizontal.

b) The void area at any transverse section of the compartment is to be assumed to be the same both before and after the grain shift, i.e. it is to be assumed that addi-

tional feeding does not occur at the time of the grain shift.

In filled compartments untrimmed which are exempted from trimming in the ends, forward and aft of the hatchway, under the provisions of [1.1.3] b), the following assumptions apply:

a) *the resulting grain surface abreast of the hatchway after shifting is to be assumed to be at an angle of 15° to the horizontal*

b) *the resulting grain surface in the ends, forward and aft of the hatchway after shifting is to be assumed to be at an angle of 25° to the horizontal.*

1.5 Assumed volumetric heeling moments in trunks

1.5.1 *After the assumed shift of grain the final void pattern is to be as shown in Fig 5.*

Note 1: If the wing spaces in way of the trunk cannot be properly trimmed in accordance with [1.1], it is to be assumed that a 25° surface shift takes place.

1.6 Assumed volumetric heeling moment of a partly filled compartment

1.6.1

a) *When the free surface of the bulk grain has not been secured in accordance with [1.9.1] to [1.9.3], [1.9.4], or [1.9.5], it is to be assumed that the grain surface after shifting is at 25° to the horizontal.*

b) *In a partly filled compartment, a division, if fitted, is to extend from one eighth of the maximum breadth of the compartment above the level of the grain surface and to the same distance below the grain surface.*

c) *In a compartment in which the longitudinal divisions are not continuous between the transverse boundaries, the length over which any such divisions are effective as devices to prevent full width shifts of grain surfaces is to be taken to be the actual length of the portion of the division under consideration less two sevenths of the greater of the transverse distances between the division and its adjacent division or ship side. This correction does not apply in the lower compartments of any combination loading in which the upper compartment is either a filled compartment or a partly filled compartment.*

1.7 Other assumptions

1.7.1 *The Society may authorise departure from the assumptions contained in these Rules in those cases where it considers this to be justified having regard to the provisions for loading or the structural arrangements, provided the stability criteria in Sec 3, [2.2.3] are met.*

Where such authorisation is granted under this regulation, particulars shall be included in the grain loading manual.

These particulars include the additional calculation of heeling moments for filled holds with untrimmed ends, an example of which is reported in [2.1].

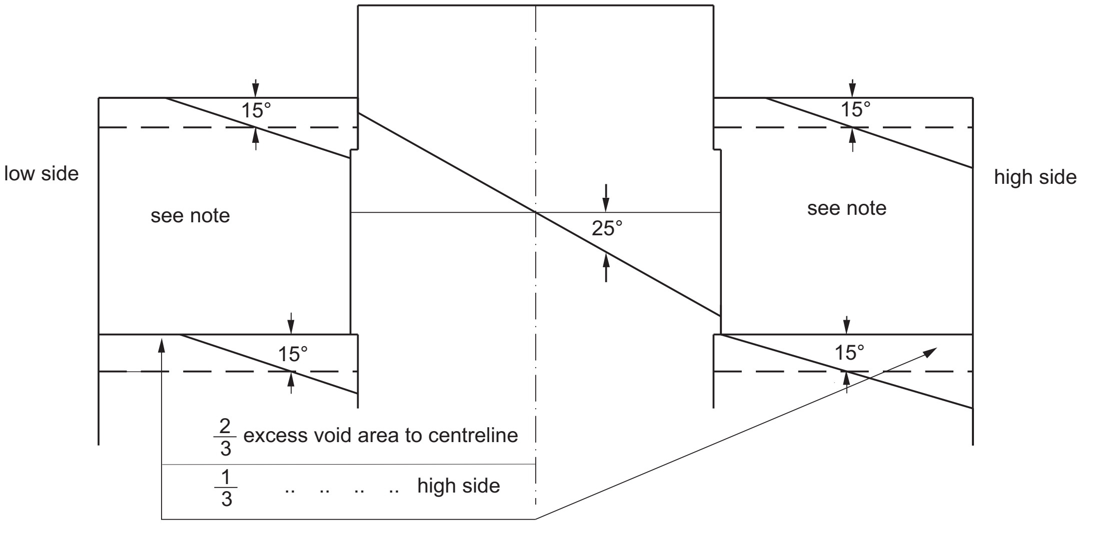
1.8 Saucers

1.8.1 *For the purpose of reducing the heeling moment a saucer may be used in place of a longitudinal division in way of a hatch opening only in a filled trimmed compartment as defined in Sec 3, [2.1.2], except in the case of linseed and other seeds having similar properties, where a saucer may not be substituted for a longitudinal division. If a longitudinal division is provided, it is to meet the requirements of [1.1.6].*

1.8.2 *The depth of the saucer, measured from the bottom of the saucer to the deck line, is to be as follows:*

- *for ships with a moulded breadth of up to 9,1 m, not less than 1,2 m*
- *for ships with a moulded breadth of 18,3 m or more, not less than 1,8 m*
- *for ships with a moulded breadth between 9,1 m and 18,3 m, the minimum depth of the saucer is to be calculated by interpolation.*

Figure 5 : Assumed volumetric heeling moment in trunks



1.8.3 *The top (mouth) of the saucer is to be formed by the underdeck structure in way of the hatchway, i.e. hatch side girders or coamings and hatch end beams. The saucer and hatchway above are to be completely filled with bagged grain or other suitable cargo laid down on a separation cloth or its equivalent and stowed tightly against adjacent structure so as to have a bearing contact with such structure to a depth equal to or greater than one half of the depth specified in [1.8.2].*

If hull structure to provide such bearing surface is not available, the saucer is to be fixed in position by steel wire rope, chain, or double steel strapping as specified in [1.9.4] d) and spaced not more than 2,4 m apart.

1.8.4 *As an alternative to filling the saucer in a filled trimmed compartment with bagged grain or other suitable cargo, a bundle of bulk grain may be used provided that:*

- *a) the dimensions and means for securing the bundle in place are the same as specified for a saucer in [1.8.2] and [1.8.3]*
- *b) the saucer is lined with a material acceptable to the Society having a tensile strength of not less than 2,687 N per 5 cm strip and which is provided with suitable means for securing at the top*
- *c) as an alternative to b), a material acceptable to the Society having a tensile strength of not less than 1,344 N per 5 cm strip may be used if the saucer is constructed as follows:*
  - *athwartship lashings acceptable to the Society are to be placed inside the saucer formed in the bulk grain at intervals of not more than 2,4 m. These lashings are to be of sufficient length to permit being drawn up tight and secured at the top of the saucer.*
  - *dunnage not less than 25 mm in thickness or other suitable material of equal strength and between 150 mm and 300 mm in width is to be placed fore and aft over these lashings to prevent the cutting or chafing of the material which is to be placed thereon to line the saucer*
- *d) the saucer is to be filled with bulk grain and secured at the top except that when using material approved under c) further dunnage is to be laid on top after lapping the material before the saucer is secured by setting up the lashings*
- *e) if more than one sheet of material is used to line the saucer they are to be joined at the bottom either by sewing or by a double lap*
- *f) the top of the saucer is to be coincidental with the bottom of the beams when these are in place and suitable general cargo or bulk grain may be placed between the beams on top of the saucer.*

1.9 Overstowing arrangements and securing

1.9.1 Bagged grain

Where bagged grain or other suitable cargo is utilised for the purpose of securing partly filled compartments, the free grain surface is to be level and is to be covered with a separation cloth or equivalent or by a suitable platform. Such platform is to consist of bearers spaced not more than 1,2 m apart and 25 mm boards laid thereon spaced not more than 100 mm apart. Platforms may be constructed of other materials provided they are deemed by the Society to be equivalent.

1.9.2 Separating platform

The platform or separation cloth is be topped off with bagged grain tightly stowed and extending to a height of not less than one sixteenth of the maximum breadth of the free grain surface or 1,2 m, whichever is the greater.

1.9.3 Equivalent cargo

The bagged grain is to be carried in sound bags which are to be well filled and securely closed.

Instead of bagged grain, other suitable cargo tightly stowed and exerting at least the same pressure as bagged grain stowed in accordance with [1.9.2] may be used.

1.9.4 Strapping or lashing

When, in order to eliminate heeling moments in partly filled compartments, strapping or lashing is utilised, the securing is to be accomplished as follows:

- *a) the grain is to be trimmed and levelled to the extent that it is very slightly crowned and covered with burlap separation cloths, tarpaulins or the equivalent*
- *b) the separation cloths and/or tarpaulins are to overlap by at least 1,8 m*
- *c) two solid floors of rough 25 mm by 150 mm to 300 mm lumber are to be laid with the top floor running longitudinally and nailed to an athwartship bottom floor. Alternatively, one solid floor of 50 mm lumber, running longitudinally and nailed over the top of a 50 mm bottom bearer not less than 150 mm wide, may be used. The bottom bearers are to extend the full breadth of the compartment and are to be spaced not more than 2,4 m apart. Arrangements utilising other materials and deemed by the Society to be equivalent to the foregoing may be accepted.*
- *d) Steel wire rope (19 mm diameter or equivalent), double steel strapping (50 mm x 1,3 mm and having a breaking load of at least 49 kN), or chain of equivalent strength, each of which is to be set tightly by means of a 32 mm turnbuckle, may be used for lashings. A winch tightener, used in conjunction with a locking arm, may be substituted for the 32 mm turnbuckle when steel strapping is used, provided suitable wrenches are available for setting up as necessary.*

  When steel strapping is used, not less than three crimp seals are to be used for securing the ends. When wire is used, not less than four clips are to be used for forming eyes in the lashings.
- *e) Prior to the completion of loading the lashings are to be positively attached to the framing at a point approximately 450 mm below the anticipated final grain surface by means of either a 25 mm shackle or beam clamp of equivalent strength*
- *f) the lashings are to be spaced not more than 2,4 m apart and each is to be supported by a bearer nailed over the top of the fore and aft floor. This bearer is to consist of lumber of not less than 25 mm by 150 mm or its equiva-*

lent and is to extend the full breadth of the compartment.

g) *During the voyage the strapping is to be regularly inspected and set up where necessary.*

1.9.5 Securing with wire mesh

When, in order to eliminate grain heeling moments in partly filled compartments, strapping or lashing is utilised, the securing may, as an alternative to the method described in [1.9.4], be accomplished as follows:

a) *the grain is to be trimmed and levelled to the extent that it is very slightly crowned along the fore and aft centreline of the compartment*

b) *the entire surface of the grain is to be covered with burlap separation cloths, tarpaulins, or the equivalent. The covering material is to have a tensile strength of not less than 1,344 N per 5 cm strip.*

c) *Two layers of wire reinforcement mesh are to be laid on top of the burlap or other covering. The bottom layer is to be laid athwartship and the top layer is to be laid longitudinally. The lengths of wire mesh are to be overlapped at least 75 mm. The top layer of mesh is to be positioned over the bottom layer in such a manner that the squares formed by the alternate layer measure approximately 75 mm by 75 mm. The wire reinforcement mesh is the type used in reinforced concrete construction. It is fabricated of 3 mm diameter steel wire having a breaking strength of not less than 52 kN/cm^2, welded in 150 mm x 150 mm squares. Wire mesh having mill scale may be used but mesh having loose, flaking rust may not be used.*

d) *The boundaries of the wire mesh, at the port and starboard side of the compartment, are to be retained by wood planks 150 mm x 50 mm,*

e) *hold-down lashings, running from side to side across the compartment, are to be spaced not more than 2,4 m apart except that the first and the last lashing are not to be more than 300 mm from the forward or after bulkhead, respectively. Prior to the completion of the loading, each lashing is to be positively attached to the framing at a point approximately 450 mm below the anticipated final grain surface by means of either a 25 mm shackle or beam clamp of equivalent strength. The lashing is to be led from this point over the top of the boundary plank described in d), which has the function of distributing the downward pressure exerted by the lashing. Two layers of 150 mm x 25 mm planks are to be laid athwartship centred beneath each lashing and extending the full breadth of the compartment.*

f) *The hold-down lashings are to consist of steel wire rope (19 mm diameter or equivalent), double steel strapping (50 mm x 1,3 mm and having a breaking load of at least 49 kN), or chain of equivalent strength, each of which is to be set tight by means of a 32 mm turnbuckle. A winch tightener, used in conjunction with a locking arm, may be substituted for the 32 mm turnbuckle when steel strapping is used, provided suitable wrenches are available for setting up as necessary. When steel strapping is used, not less than three crimp seals are to be used for securing the ends. When wire rope is used, not less than four clips are to be used for forming eyes in the lashings.*

g) *During the voyage the hold-down lashings are to be regularly inspected and set up where necessary.*

2 Dispensation from trimming ends of holds in certain ships

2.1 Calculation example

2.1.1 General

As a result of the provisions in [1.1.3] and [1.7.1], *dispensation may be granted from trimming the ends of holds in specially suitable ships, when requested, provided that an additional entry of heeling moments for filled holds with untrimmed ends is approved and included in the* grain loading manual required in Sec 3, [2.2.2]. *Untrimmed ends are to be treated as partly filled spaces and, accordingly, the grain surface in these portions of the hold is to be assumed to shift to an angle of 25° from the horizontal.*

After taking into account the heeling moments due to the shift of grain in the untrimmed ends, dispensation may be granted provided the ship meets the stability criteria specified in Sec 3, [2.2.3].

This dispensation may be granted only to ships which are arranged with sloping bulkheads, port and starboard forming the longitudinal inner boundaries of topside tanks and which slope at an angle of 30° or more to the horizontal.

When calculating the geometry of the void beyond the hatch end, allowance may be made for feeding holes in the hatch end beam provided they meet the requirements reported in Tab 2.

The effective depth is to be taken as the distance from the underside of the deck to a horizontal line on the hatch end beam which is the mean between the peaks and valleys of the actual grain surface as shown in Fig 1.

2.1.2 Assumptions

In performing the calculation of the volumetric heeling moment, the grain in the hatchway is assumed to be filled to the maximum and the resulting surface shifted to an angle of 15° to the horizontal.

In the untrimmed end the surface of the grain will slope in all directions away from the filling area at an angle of 30° to the horizontal from the lower edge of the hatch end beam or, in certain cases from a higher level where feeding holes are provided.

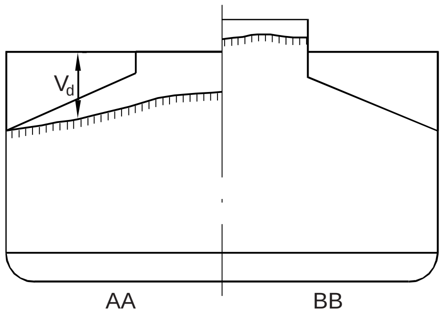
The sum of the moments calculated for the ends and the moments for the hatchway give the total volumetric heeling moment for the compartment "filled - ends not trimmed" and is to be listed for any such compartment in the grain loading manual.

The information concerning full holds assumed to be trimmed and partly filled holds is to remain the same as at present.

2.1.3 Calculation of void areas

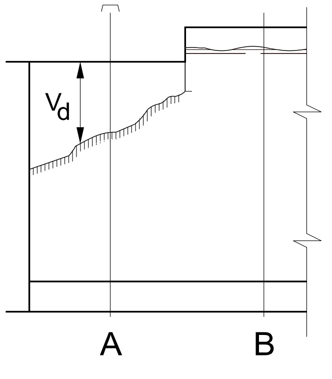
In ships having sloping topside tanks in each hold, the grain surface leans against topside tank bulkheads if its slope is equal to or greater than 30° to the horizontal; in this case no void occurs and the grain surface location is that illustrated in Fig 6.

Figure 6 : Void depth - Transverse section



In the zone forward and abaft the hatch, the grain surface is located so as that the standard void depth V_d increases with the distance from the hatch, as shown in Fig 7.

Figure 7 : Void depth - Longitudinal section



For the void depth calculation, three different transversal sections, AA, BB and CC are taken into account, and for each of these sections, three different points (A_1, A_2, A_3, B_1, B_2, B_3 and C_1, C_2, C_3) are to be considered, as illustrated in Fig 8.

The distance between the points C_3 and B_2, in m, is as follows:

$$C_3B_2 = \sqrt{(3^2 + 2^2)} = 3{,}61$$

and the void depth V_{d2}, in m, measured in B_2 is:

$$V_{d2} = 3{,}61 \tan 30^o + 0{,}60 = 2{,}68$$

The topside tank area A_W, in m², (I + II) is as follows:

$$A_W = (6 \cdot 0{,}60) + \frac{6(\tan 30^o)6}{2} = 13{,}99$$

The void depth V_{d3}, V_{d2}, V_{d1}, in m, relevant to points A_3, A_2, A_1 of section AA is:

$$V_{d3} = 4 \tan 30^o + 0{,}60 = 2{,}91$$

$$V_{d2} = (\sqrt{3^2 + 4^2}) \tan 30^o + 0{,}60 = 3{,}49$$

$$V_{d1} = (\sqrt{6^2 + 4^2}) \tan 30^o + 0{,}60 = 4{,}76$$

The area $A_{V,AA}$, in m², of the void in transversal section AA (calculated according to Simpson's integration rule) is as follows:

$$A_{V,AA} = \frac{A_1A_2}{3} \cdot (V_{d3} + 4 \cdot V_{d2} + V_{d1}) = 21{,}63$$

Figure 8 : Geometry for void depth calculation

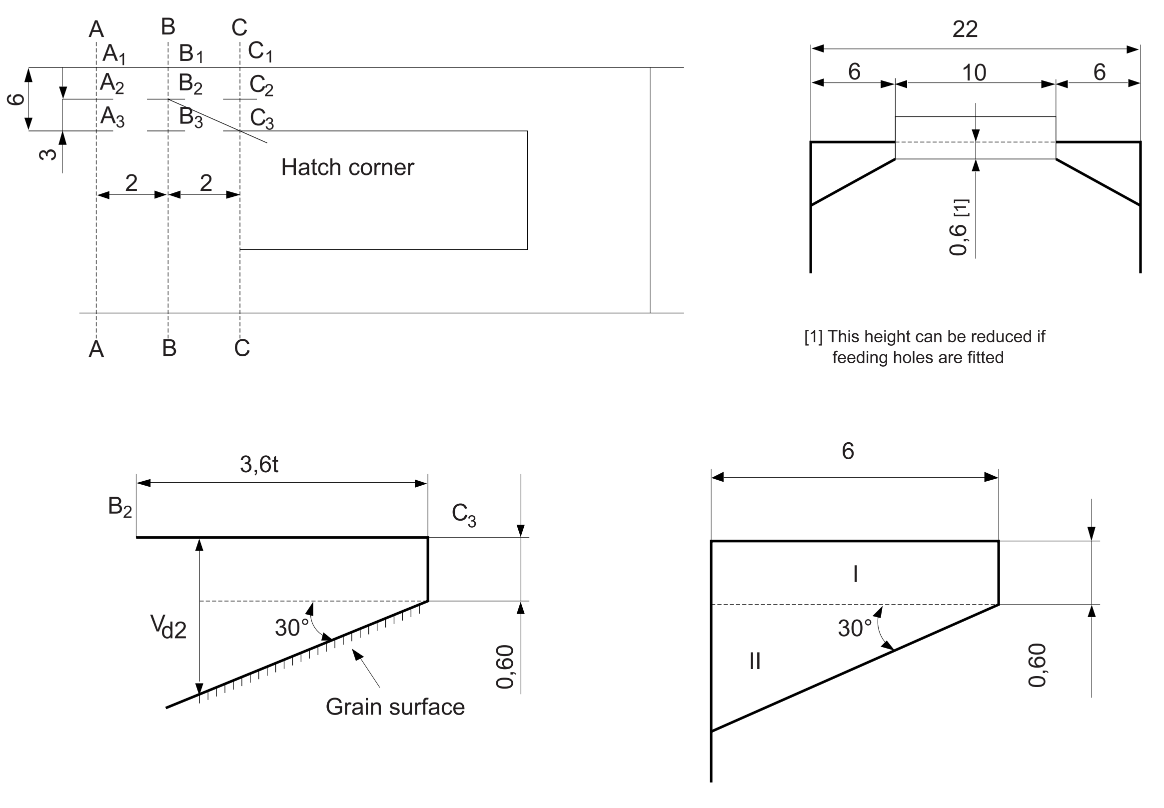


Figure 9 : Geometry for void depth calculation

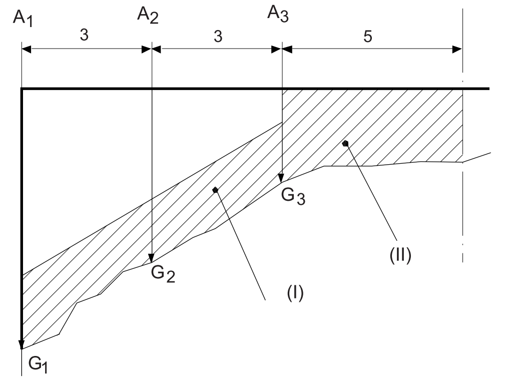
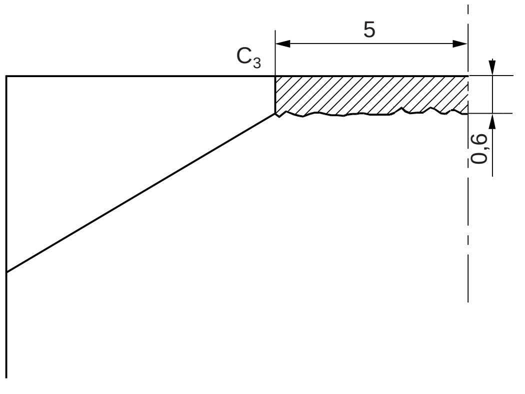


Figure 10 : Geometry for void depth calculation



With reference to Fig 9 and Fig 10 the following areas are calculated:

- area $A_1A_3G_1G_3$ (which is the area $A_{V,AA}$ calculated above), in m^2, equal to: 21,63
- topside tank area A_W, in m^2, equal to: 13,98
- area $A_{V,I}$, in m^2, relevant to void I, equal to:

  $A_{V,I}$ = 21,63 - 13,99 = 7,64
- area $A_{V,II}$, in m^2, relevant to void II, equal to:

  $A_{V,II} = 5 \cdot 2,91 = 14,55$
- total area $A_{T,AA}$ of void, port and starboard, in m^2, in section AA, equal to:

  $A_{T,AA}$ = 2 (7,64 + 14,55) = 44,38

With the same procedure the void relevant to the BB section is calculated, as follows:

- total area $A_{T,BB}$ of void, port and starboard, in m^2, in section BB:

  $A_{T,BB}$ = 22,98
- total area $A_{T,CC}$ of void, port and starboard, in m^2, in section CC:

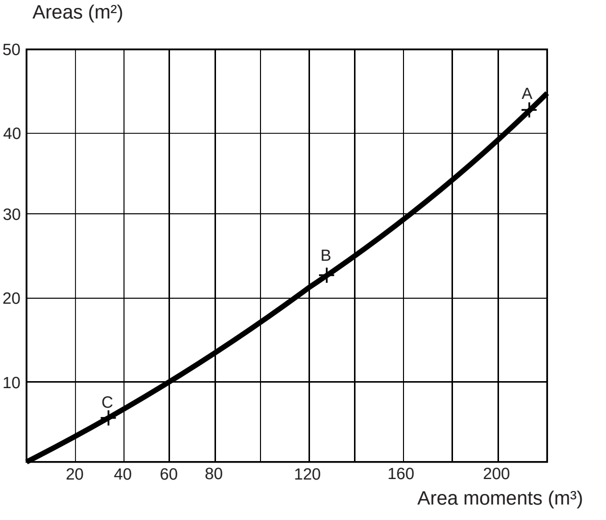
  $A_{T,CC} = 2\ (5 \cdot 0,60) = 6,00$

2.1.4 Calculation of areas and area moments

Finding the surface at each station after shift which establishes a void area exactly equal to that at the station before shift is a complicated calculation if done directly.

However, if the areas and corresponding area moments are calculated for random shifts from the horizontal to 25°, and a plot is made of areas versus area moments, then by entering the plot with the actual void area at any position before shift, a close approximation to the area moment after shift can be obtained. Such a plot is provided in Fig 11.

Figure 11 : Plot of areas versus area moments



Another advantage of this method lies in the fact that while the lengths of the end sections may vary, the cross-sectional dimensions are usually uniform throughout most of the ship. Therefore the same plot of areas versus area moments can be used for several locations.

With reference to Fig 12, the areas relevant to the zones 1, 2, 3 are as follows:

- area A_1, in m^2, relevant to zone 1:

$$A_1 = \frac{8,74(\tan 25^o)8,74}{2} - 3,99 = 3,82$$

- area A_2, in m^2, relevant to zone 2:

$$A_2 = \frac{13(\tan 25^o)13}{2} - 13,99 = 25,41$$

- area A_3, in m^2, relevant to zone 3:

$$A_3 = \frac{16(\tan 25^o)16}{2} - 13,99 = 45,70$$

The area moments M_1, M_2, M_3, in m^3 relevant to areas A_1, A_2, A_3, referred to the centreline are as follows:

- area moment M_1:

$$M_1 = 17,81\left(\frac{2}{3}.8,74 + 2,26\right) - 3,6(3+5) - 10,38\left(\frac{2}{3}.6 + 5\right)$$
$$= 21,80$$

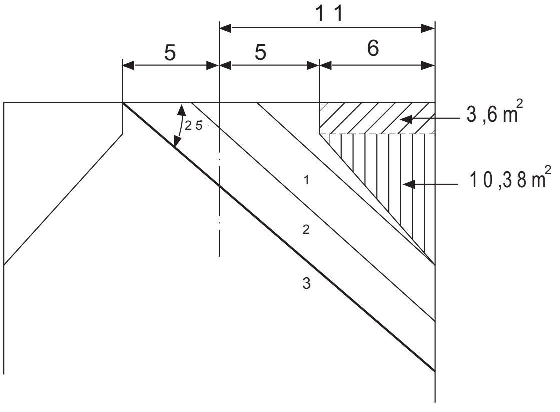
- area moment M_2:

$$M_2 = 39,39\left(\frac{2}{3}.13 - 2\right) - 3,6(3+5) - 10,38\left(\frac{2}{3}.6 + 5\right)$$
$$= 140,38$$

- area moment M_3:

$$M_3 = 59,68\left(\frac{2}{3}.16 - 5\right) - 3,6(3+5) - 10,38\left(\frac{2}{3}.6 + 5\right)$$
$$= 215,97$$

Figure 12 : Geometry for void depth calculation



A summary of the values obtained is reported in Tab 3.

Table 3 : Areas and area moments

Zone	Area, in m^2	Area moment in m^3
1	3,83	21,80
2	25,41	140,38
3	45,70	215,97

Table 4 : Total volumetric heeling moment in a hold, with untrimmed ends

Hold zone	Heeling moment, in m^4
Fore end	505,33
Hatch	236,25
Aft end	505,33
Total	1246,91

2.1.5 Calculation of volumetric heeling moment

a) Volumetric heeling moment in untrimmed end.

Tab 4 gives the values of areas and area moments derived from the plot in Fig 11.

Therefore, the longitudinal distance between points A, B, C being equal to 2 m, the volumetric heeling moment in the untrimmed end M^I, in m^4, is as follows:

$$M^I = \frac{2}{3}[1 \cdot 34 + 4 \cdot 128 + 1 \cdot 212] = 505{,}33$$

b) Volumetric heeling moment in hatch.

The following calculation is valid for void spaces within the hatch (see Fig 13).

- void area A_H, in m^2:

$$A_H = 10(0{,}4 + 0{,}15) = 5{,}5$$

- centre of gravity x, in m, relevant to A_H:

$$x = \sqrt{\frac{5{,}5 \cdot 2}{\tan 15^\circ}} = 6{,}41$$

- area moment M_H, in m^3:

$$M_H = 5{,}5\left(5 - \frac{6{,}41}{3}\right) = 15{,}75$$

Figure 13 : Volumetric heeling moment in hatch

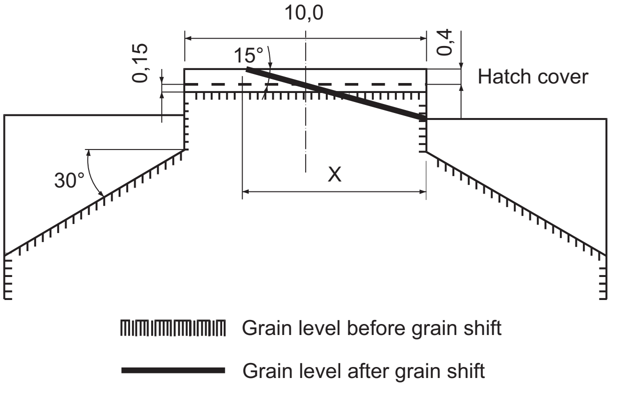
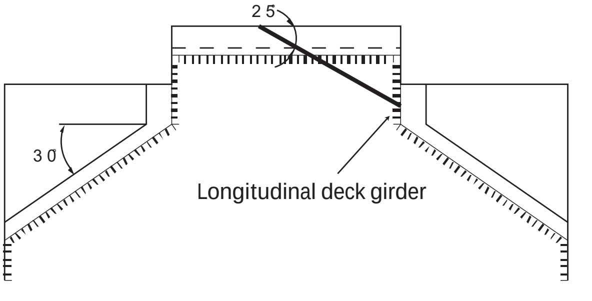


Figure 14 : Possible void relevant to a longitudinal deck girder



The hatch length being equal to 15 m, the volumetric heeling moment in hatch M^{II}, in m^4, is as follows:

$$M^{II} = 15{,}75 \cdot 15 = 236{,}25$$

In addition, the possible void relevant to a longitudinal deck girder as described in Fig 14, as well as the possible void relevant to the topside tank geometry as described in Fig 15, are to be taken into account; on the contrary, the possible void relevant to topside tank longitudinal stiffeners as described in Fig 16 may not be taken into account.

c) Volumetric heeling moment

The total volumetric heeling moment in a hold, as reported in Tab 4, is the sum of the contribution of a) and b) above.

Figure 15 : Possible void relevant to the topside tank geometry

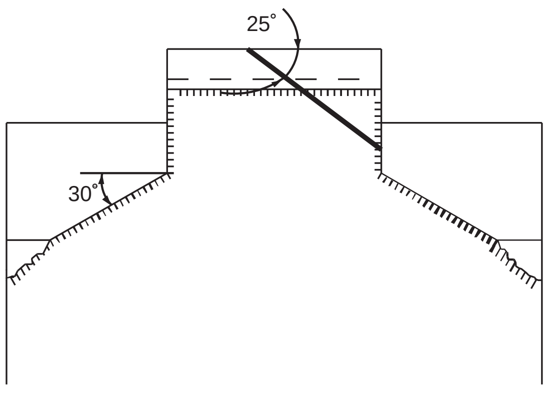
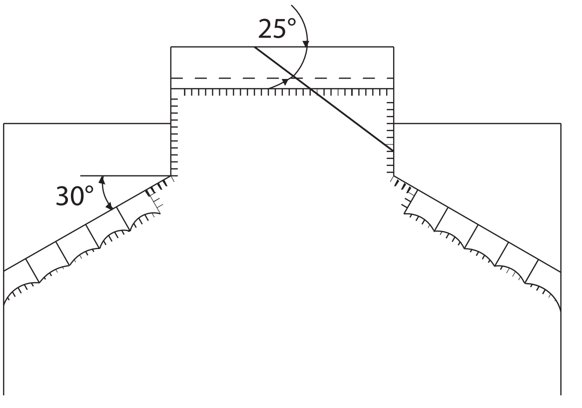


Figure 16 : Possible void relevant to topside tank longitudinal stiffeners



Part E
Service Notations

Chapter 5
ORE CARRIERS

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 Ships complying with the requirements of this Chapter are eligilble for the assignment of the service notation **ore carrier**, as defined in Pt A, Ch 1, Sec 2, [4.3.5].

1.1.2 Ships dealt with in this Chapter are to comply with the requirements stipulated in Part A, Part C and Part D of the Rules, as applicable, and with the requirements of this Chapter, which are specific to ore carriers.

1.2 Summary table

1.2.1 Tab 1 indicates, for easy reference, the Sections of this Chapter dealing with requirements applicable to ore carriers.

Table 1

Main subject	Reference
Ship arrangement	Sec 2
Hull and stability	Sec 3
Machinery	**(1)**
Electrical installations	**(1)**
Automation	**(1)**
Fire protection, detection and extinction	**(1)**

(1) No specific requirements for ore carriers are given in this Chapter.

SECTION 2 SHIP ARRANGEMENT

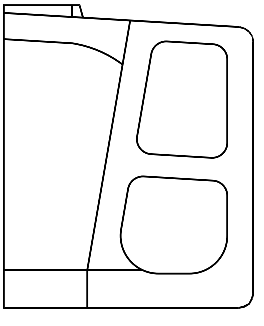
1 General

1.1 Application

1.1.1 The requirements of Sec 2 and Sec 3 apply to single deck ships with two longitudinal bulkheads and a double bottom throughout the cargo region and intended to carry dry cargoes in bulk, including ore cargo, in the centre holds only. A typical midship section is shown in Fig 1.

The application of these requirements to other ship types is to be considered by the Society on a case-by-case basis.

Figure 1 : Ore carrier



2 General arrangement design

2.1 Access arrangement to double bottom and pipe tunnel

2.1.1 Means of access

Adequate means of access to the double bottom and pipe tunnel are to be provided.

2.1.2 Manholes in the inner bottom, floors and girders

Manholes cut in the inner bottom are to be located at a minimum distance of one floor spacing from the lower stool.

The location and size of manholes in floors and girders are to be determined to facilitate the access to double bottom structures and their ventilation. However, they are to be avoided in the areas where high shear stresses may occur.

2.2 Access arrangement to cargo holds

2.2.1 Means of access

As far as practicable, permanent or movable means of access stored on board are to be provided to ensure proper survey and maintenance of cargo holds.

2.2.2 Hatches of large cargo holds

If separate hatches are used as access to the ladders as required in [2.2.3], each hatch is to have a clear opening of at least 600 mm x 600 mm.

When the access to the cargo hold is arranged through the cargo hatch, the top of the ladder is to be placed as close as possible to the hatch coaming.

Accesses and ladders are to be so arranged that personnel equipped with self-contained breathing apparatus may readily enter and leave the cargo hold.

Access hatch coamings having a height greater than 900 mm are also to have steps on the outside in conjunction with cargo hold ladders.

2.2.3 Ladders within large cargo holds

Each cargo hold is to be provided with at least two ladders as far apart as practicable longitudinally. If possible these ladders are to be arranged diagonally, e.g. one ladder near the forward bulkhead on the port side, the other one near the aft bulkhead on the starboard side, from the ship's centreline.

Ladders are to be so designed and arranged that the risk of damage from the cargo handling gear is minimised.

Vertical ladders may be permitted provided they are arranged above each other in line with other ladders to which they form access and resting positions are provided at not more than 9 metres apart.

Tunnels passing through cargo holds are to be equipped with ladders or steps at each end of the hold so that personnel may get across such tunnels.

Where it may be necessary for work to be carried out within a cargo hold preparatory to loading, consideration is to be given to suitable arrangements for the safe handling of portable staging or movable platforms.

SECTION 3 HULL AND STABILITY

Symbols

R_y : Minimum yield stress, in N/mm², of the material, to be taken equal to 235/k N/mm², unless otherwise specified

k : Material factor for steel, defined in Pt B, Ch 4, Sec 1, [2.3]

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

- E = 2,06.10⁵ N/mm² for steels in general
- E = 1,95.10⁵ N/mm² for stainless steels.

1 General

1.1 Loading manual and loading instruments

1.1.1 The specific requirements in Pt B, Ch 11, Sec 2 for ships with the service notation **ore carrier ESP** and equal to or greater than 150 m in length are to be complied with.

2 Stability

2.1 Intact stability

2.1.1 General

The stability of the ship for the loading conditions in Pt B, Ch 3, App 2, [1.2.5] is to be in compliance with the requirements in Pt B, Ch 3, Sec 2. Where the ship is intended also for the carriage of grain, the requirements in Ch 4, Sec 3, [2.2.2] and Ch 4, Sec 3, [2.2.3] are to be complied with.

3 Design loads

3.1 Hull girder loads

3.1.1 Still water loads *(1/1/2022)*

In addition to the requirements in Pt B, Ch 5, Sec 2, [2.1.2], still water loads are to be calculated for the following loading conditions, subdivided into departure and arrival conditions as appropriate:

- alternate light and heavy cargo loading conditions at maximum draught
- homogeneous light and heavy cargo loading conditions at maximum draught

Figure 1 : Symmetrical gusset/shedder plates

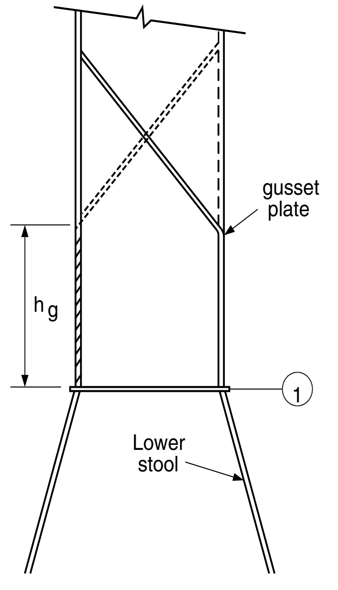
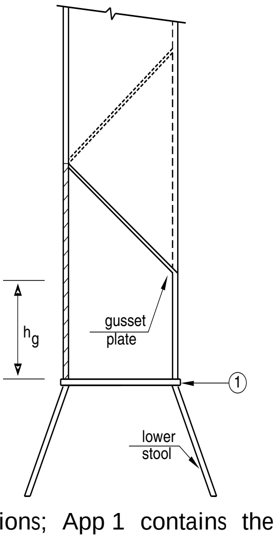


Figure 2 : Asymmetrical gusset/shedder plates

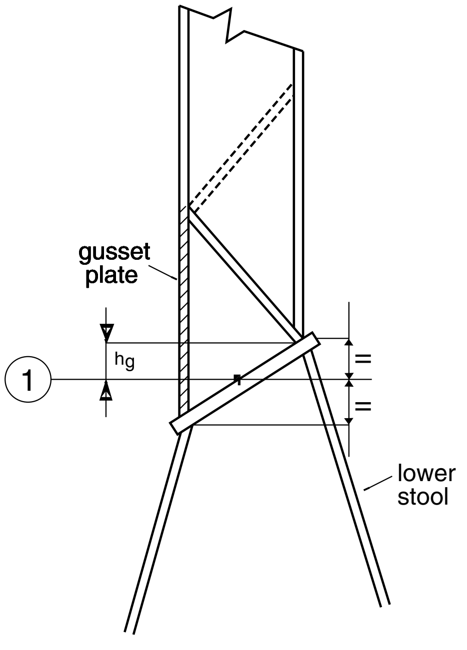


- ballast conditions; App 1 contains the guidance for partially filled ballast tanks in ballast loading conditions.
- short voyage conditions where the ship is to be loaded to maximum draught but with a limited amount of bunkers
- multiple port loading/unloading conditions
- deck cargo conditions, where applicable
- typical loading sequences where the ship is loaded from commencement of cargo loading to reaching full deadweight capacity, for homogeneous conditions, relevant part load conditions and alternate conditions where applicable. Typical unloading sequences for these conditions are also to be included. The typical

loading/unloading sequences are also to be developed so as not to exceed applicable strength limitations. The typical loading sequences are also to be developed paying due attention to the loading rate and deballasting capability.

- typical sequences for change of ballast at sea, where applicable.

Figure 3 : Asymmetrical gusset/shedder plates Sloping stool top plate



4 Structure design principles

4.1 Double bottom structure

4.1.1 The double bottom is to be longitudinally framed.

The girder spacing is to be not greater than 4 times the spacing of bottom or inner bottom ordinary stiffeners and the floor spacing is to be not greater than 3 frame spaces.

Solid floors are to be fitted in line with the transverse primary supporting members in wing tanks and intermediate floors are to be added at mid-span between primary supporting members.

4.1.2 Other arrangements may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo holds.

4.1.3 Scarfing of the double bottom structure into the wing tanks is to be properly ensured. The inner bottom plating is generally to be prolonged within the wing tanks by adequately sized horizontal brackets in way of floors.

4.2 Side structure

4.2.1 In ships greater than 120 m in length, the side shell is to be longitudinally framed.

In general, the spacing of vertical primary supporting members is to be not greater than 6 times the frame spacing.

4.2.2 Other arrangements may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo hold.

4.3 Deck structure

4.3.1 The deck outside the line of hatches is to be longitudinally framed.

4.3.2 The cross decks between hatches are generally to be transversely framed.

4.3.3 The connection of hatch end beams with deck structures is to be properly ensured by fitting inside the wing tanks additional web frames or brackets.

4.4 Longitudinal bulkhead structure

4.4.1 Longitudinals bulkheads are to be plane, but they may be knuckled in the upper and lower parts to form a hopper. In such cases, the design of the knuckles and the adjacent structures is to be considered by the Society on a case-by-case basis.

4.4.2 In ships greater than 120 m in length, longitudinal bulkheads are to be longitudinally framed.

4.4.3 Other arrangements may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo hold.

4.5 Transverse bulkhead structure

4.5.1 Where the structural arrangement of transverse bulkheads in wing tanks is different from that in centre holds, arrangements are to be made to ensure continuity of the transverse strength through the longitudinal bulkheads.

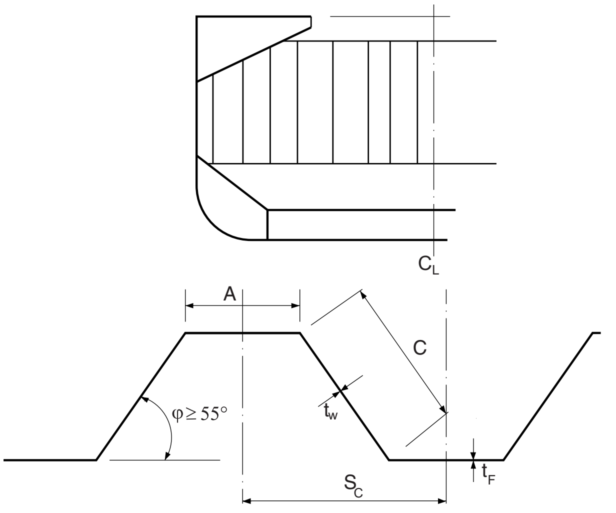
4.6 Transverse vertically corrugated watertight bulkheads

4.6.1 General

Transverse vertically corrugated watertight bulkheads are generally to be fitted with a lower stool and an upper stool below the deck.

The corrugation angle φ shown in Fig 4 is to be not less than 55°.

Figure 4 : Corrugation geometry

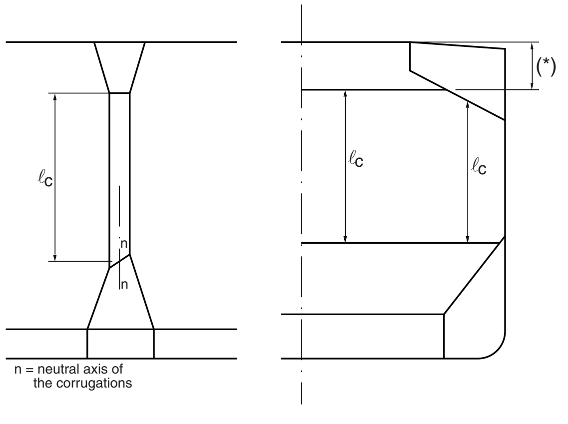


4.6.2 Span of corrugations

The span ℓ_C of the corrugations (to be used for carrying out the strength checks according to Pt B, Ch 7, Sec 2 or Pt B, Ch 8, Sec 4, as the case may be) is to be taken as the distance shown in Fig 5. For the definition of ℓ_C, the internal end of the upper stool may not be taken at a distance from the deck at centreline greater than:

- 3 times the depth of corrugations, in general
- twice the depth of corrugations, for rectangular upper stools.

Figure 5 : Span of the corrugations



(*) See [4.6.2].

4.6.3 Lower stool *(1/7/2001)*

The lower stool is to have a height in general not less than 3 times the depth of the corrugations.

The thickness and material of the stool top plate are to be not less than those required for the bulkhead plating above. The thickness and material properties of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top are to be not less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at the lower end of corrugation.

The ends of stool side ordinary stiffeners are to be attached to brackets at the upper and lower ends of the stool.

The distance from the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with Fig 6 .

The stool bottom is to be installed in line with double bottom floors and is to have a width not less than 2,5 times the mean depth of the corrugation.

The stool is to be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate are to be avoided.

Where corrugations are cut at the lower stool, the weld connections of corrugations and stool side plating to the stool top plate are to be in accordance with [9.1]. The weld connections of stool side plating and supporting floors to the inner bottom plating are to be in accordance with [9.1].

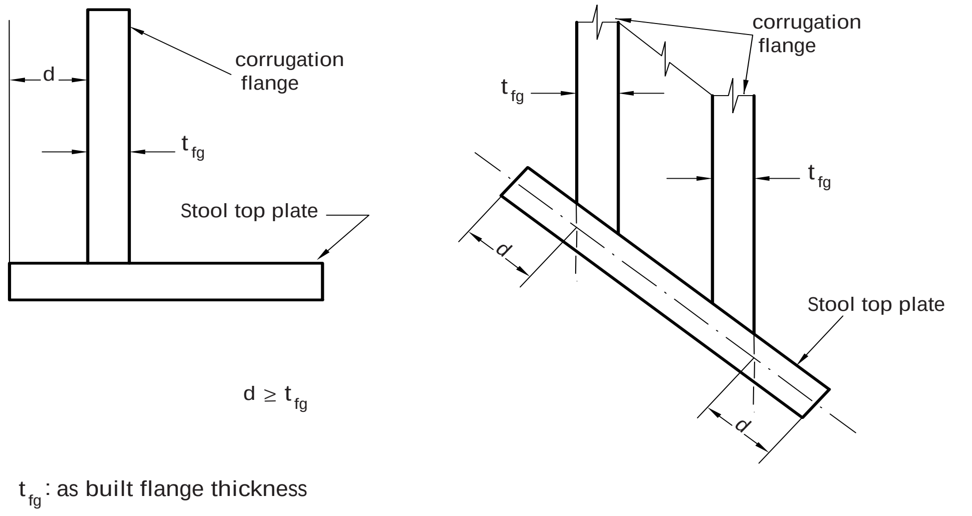
4.6.4 Upper stool

The upper stool is to have a height in general between 2 and 3 times the depth of corrugations. Rectangular stools are to have a height in general equal to twice the depth of corrugations, measured from the deck level and at the hatch side girder.

The upper stool is to be properly supported by deck girders or deep brackets between the adjacent hatch end beams.

The width of the upper stool bottom plate is generally to be the same as that of the lower stool top plate. The stool top of non-rectangular stools is to have a width not less than twice the depth of corrugations.

Figure 6 : Permitted distance, d, from the edge of the stool top plate to the surface of the corrugation flange



The thickness and material of the stool bottom plate are to be the same as those of the bulkhead plating below. The thickness of the lower portion of stool side plating is to be not less than 80% of that required for the upper part of the bulkhead plating where the same material is used.

The ends of stool side ordinary stiffeners are to be attached to brackets at the upper and lower end of the stool.

The stool is to be fitted with diaphragms in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate are to be avoided.

4.6.5 Alignment

Stool side plating is to align with the corrugation flanges; lower stool side vertical stiffeners and their brackets in the stool are to align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Lower stool side plating may not be knuckled anywhere between the inner bottom plating and the stool top plate.

4.6.6 Effective width of the compression flange

The effective width of the corrugation flange to be considered for the strength check of the bulkhead is to be obtained, in m, from the following formula:

$$b_{EF} = C_E A$$

where:

C_E : Coefficient to be taken equal to:

$$C_E = \frac{2,25}{\beta} - \frac{1,25}{\beta^2} \qquad \text{for } \beta > 1,25$$

$$C_E = 1,0 \qquad \text{for } \beta \le 1,25$$

β : Coefficient to be taken equal to:

$$\beta = 10^3 \frac{A}{t_f} \sqrt{\frac{R_{eH}}{E}}$$

A : Width, in m, of the corrugation flange (see Fig 4)

t_f : Net flange thickness, in mm

R_{eH} : Minimum yield stress, in N/mm², of the flange material, defined in Pt B, Ch 4, Sec 1, [2].

4.6.7 Effective shedder plates

Effective shedder plates are those which:

- are not knuckled
- are welded to the corrugations and the lower stool top plate according to [9.1]
- are fitted with a minimum slope of 45°, their lower edge being in line with the lower stool side plating
- have thickness not less than 75% of that required for the corrugation flanges
- have material properties not less than those required for the flanges.

4.6.8 Effective gusset plates

Effective gusset plates are those which:

- are in combination with shedder plates having thickness, material properties and welded connections according to [4.6.7]
- have a height not less than half of the flange width
- are fitted in line with the lower stool side plating
- are welded to the lower stool plate, corrugations and shedder plates according to [9.1]
- have thickness and material properties not less than those required for the flanges.

4.6.9 Section modulus at the lower end of corrugations

a) The section modulus at the lower end of corrugations (sections 1 in Fig 7 to Fig 3) is to be calculated with the compression flange having an effective flange width b_{ef} not larger than that indicated in [4.6.6].

b) Webs not supported by local brackets.

Except in case e), if the corrugation webs are not supported by local brackets below the stool top plate in the lower part, the section modulus of the corrugations is to be calculated considering the corrugation webs 30% effective.

c) Effective shedder plates.

Provided that effective shedder plates, as defined in [4.6.7], are fitted (see Fig 7 and Fig 8), when calculating the section modulus of corrugations at the lower end (sections 1 in Fig 7 and Fig 8), the area of flange plates may be increased by the value obtained, in cm², from the following formula:

$$I_{SH} = 2{,}5A\sqrt{t_F t_{SH}}$$

without being taken greater than $2{,}5At_F$,

where:

A : Width, in m, of the corrugation flange (see Fig 4)

t_{SH} : Net shedder plate thickness, in mm

t_F : Net flange thickness, in mm.

d) Effective gusset plates.

Provided that effective gusset plates, as defined in [4.6.8], are fitted (see Fig 1 to Fig 3), when calculating the section modulus of corrugations at the lower end (cross-sections 1 in Fig 1 to Fig 3), the area of flange plates may be increased by the value obtained, in cm², from the following formula:

$$I_G = 7h_G t_F$$

where:

h_G : Height, in m, of gusset plates (see Fig 1 to Fig 3), to be taken not greater than $(10/7)S_{GU}$

S_{GU} : Width, in m, of gusset plates

t_F : Net flange thickness, in mm, based on the as-built condition.

e) Sloping stool top plate

If the corrugation webs are welded to a sloping stool top plate which has an angle not less than 45° with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. For angles less than 45°, the effectiveness of the web may be obtained by linear interpolation between 30% for 0° and 100% for 45°.

Where effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in d) above. No credit may be given to shedder plates only.

4.6.10 Section modulus at sections other than the lower end of corrugations

The section modulus is to be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{EF}, not larger than that obtained in [4.6.6].

4.6.11 Shear area

The shear area is to be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin φ ,)φ being the angle between the web and the flange (see Fig 4).

Figure 7 : Symmetrical shedder plates

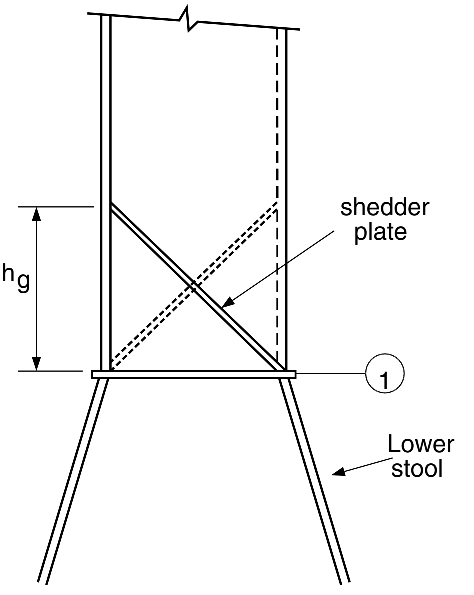
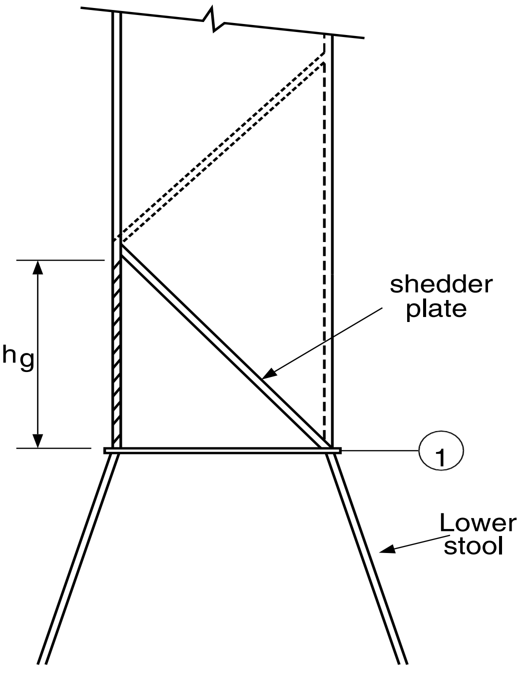


Figure 8 : Asymmetrical shedder plates



5 Hull scantlings

5.1 Additional requirements

5.1.1 Minimum net thicknesses of the inner bottom plating

The net thickness of the inner bottom plating in holds is to be not less than the value given in Tab 1.

Table 1 : Minimum net thickness of the inner bottom plating in holds

Plating	Minimum net thickness, in mm	
Inner bottom in holds	Longitudinal framing	$2,15\,(L^{1/3}\,k^{1/6}) + 4,5\,s$
	Transverse framing	$2,35\,(L^{1/3}\,k^{1/6}) + 4,5\,s$
Note 1: s : Length, in m, of the shorter side of the plate panel.		

5.2 Strength checks of cross-ties analysed through a three dimensional beam model

5.2.1 General

Cross-ties analysed through three dimensional beam model analyses according to Pt B, Ch 7, Sec 3 are to be considered, in the most general case, as being subjected to axial forces and bending moments around the neutral axis perpendicular to the cross-tie web. This axis is identified as the y axis, while the x axis is that in the web plane (see Figures in Tab 2).

The axial force may be either tensile or compression. Depending on this, two types of checks are to be carried out, according to [5.2.2] or [5.2.3], respectively.

5.2.2 Strength check of cross-ties subjected to axial tensile forces and bending moments

The net scantlings of cross-ties are to comply with the following formula:

$$10\frac{F_T}{A_{ct}} + 10^3\frac{M}{w_{yy}} \le \frac{R_y}{\gamma_R\gamma_m}$$

where:

F_T : Axial tensile force, in kN, in the cross-ties, obtained from the structural analysis

A_{ct} : Net sectional area, in cm², of the cross-tie

M : Max ($|M_1|$, $|M_2|$)

M_1, M_2 : Algebraic bending moments, in kN.m, around the y axis at the ends of the cross-tie, obtained from the structural analysis,

w_{yy} : Net section modulus, in cm³, of the cross-tie about the y axis

γ_R : Resistance partial safety factor:

$\gamma_R = 1,02$

γ_m : Material partial safety factor:

$\gamma_m = 1,02$

5.2.3 Strength check of cross-ties subjected to axial compressive forces and bending moments

The net scantlings of cross-ties are to comply with the following formula:

$$10F_C\left(\frac{1}{A_{ct}} + \frac{\Phi e}{w_{xx}}\right) \le \frac{R_y}{\gamma_R\gamma_m}$$

$$10\frac{F_C}{A_{ct}} + 10^3\frac{M_{max}}{w_{yy}} \le \frac{R_y}{\gamma_R\gamma_m}$$

where:

F_C : Axial compressive force, in kN, in the cross-ties, obtained from the structural analysis

A_{ct} : Net cross-sectional area, in cm², of the cross-tie

$$\Phi = \frac{1}{1 - \frac{F_C}{F_{EX}}}$$

F_{EX} : Euler load, in kN, for buckling around the x axis:

$$F_{EX} = \frac{\pi^2 E I_{xx}}{10^5 \ell^2}$$

I_{xx} : Net moment of inertia, in cm⁴, of the cross-tie about the x axis

ℓ : Span, in m, of the cross-tie

e : Distance, in cm, from the centre of gravity to the web of the cross-tie, specified in Tab 2 for various types of profiles

w_{ww} : Net section modulus, in cm³, of the cross-tie about the x axis

M_{max} : Max ($|M_0|$, $|M_1|$, $|M_2|$)

$$M_0 = \frac{\sqrt{1+t^2}(M_1 + M_2)}{2\cos(u)}$$

$$t = \frac{1}{\tan(u)}\left(\frac{M_2 - M_1}{M_2 + M_1}\right)$$

$$u = \frac{\pi}{2}\sqrt{\frac{F_C}{F_{EY}}}$$

F_{EY} : Euler load, in kN, for buckling around the y axis:

$$F_{EY} = \frac{\pi^2 E I_{yy}}{10^5 \ell^2}$$

I_{yy} : Net moment of inertia, in cm⁴, of the cross-tie about the y axis

M_1,M_2 : Algebraic bending moments, in kN.m, around the y axis at the ends of the cross-tie, obtained from the structural analysis

w_{yy} : Net section modulus, in cm³, of the cross-tie about the y axis

γ_R : Resistance partial safety factor:

$\gamma_R = 1,02$

γ_m : Material partial safety factor:

$\gamma_m = 1,02$

5.3 Strength checks of cross-ties analysed through a three dimensional finite element model

5.3.1 In addition to the requirements in Pt B, Ch 7, Sec 3, [4] and Pt B, Ch 7, Sec 3, [6], the net scantlings of cross-ties subjected to compression axial stresses are to comply with the following formula:

$$|\sigma| \le \frac{\sigma_C}{\gamma_R\gamma_m}$$

where:

σ : Compressive stress, in N/mm², obtained from a three dimensional finite element analysis, based on fine mesh modelling, according to Pt B, Ch 7, Sec 3 and Pt B, Ch 7, App 1

σ_c : Critical stress, in N/mm², defined in [5.3.2]

γ_R : Resistance partial safety factor:

$\gamma_R = 1{,}02$

γ_m : Material partial safety factor:

$\gamma_m = 1{,}02$

5.3.2 The critical buckling stress of cross-ties is to be obtained, in N/mm², from the following formulae:

$$\sigma_c = \sigma_E \quad \text{for} \quad \sigma_E \le \frac{R_y}{2}$$

$$\sigma_c = R_y\left(1 - \frac{R_y}{4\sigma_E}\right) \quad \text{for} \quad \sigma_E > \frac{R_y}{2}$$

where:

$\sigma_E = \text{Min}(\sigma_{E1}, \sigma_{E2})$,

σ_{E1} : Euler flexural buckling stress, to be obtained, in N/mm², from the following formula:

$$\sigma_{E1} = \frac{\pi^2 EI}{10^4 A_{ct} \ell^2}$$

I : Min (I_{xx}, I_{yy})

I_{xx} : Net moment of inertia, in cm⁴, of the cross-tie about the x axis defined in [5.2.1]

I_{yy} : Net moment of inertia, in cm⁴, of the cross-tie about the y axis defined in [5.2.1]

A_{ct} : Net cross-sectional area, in cm², of the cross-tie

ℓ : Span, in m, of the cross-tie

σ_{E2} : Euler torsional buckling stress, to be obtained, in N/mm², from the following formula:

$$\sigma_{E2} = \frac{\pi^2 E I_w}{10^4 I_o \ell^2} + 0{,}41 E \frac{J}{I_o}$$

I_w : Net sectorial moment of inertia, in cm⁴, of the cross-tie, specified in Tab 2 for various types of profiles

I_o : Net polar moment of inertia, in cm⁴, of the cross-tie,

$$I_o = I_{xx} + I_{yy} + A_{ct}(y_o + e)^2$$

y_o : Distance, in cm, from the centre of torsion to the web of the cross-tie, specified in Tab 2 for various types of profiles

e : Distance, in cm, from the centre of gravity to the web of the cross-tie, specified in Tab 2 for various types of profiles

J : St. Venant's net moment of inertia, in cm⁴, of the cross-tie, specified in Tab 2 for various types of profiles.

6 Hatch covers, hatch coamings and closing devices

6.1 Application

6.1.1 *(1/7/2024)*

Refer to the requirements for Type 2 ships in Pt B, Ch 9, Sec 7.

7 Hull outfitting

7.1 Forecastle

7.1.1 General *(1/1/2004)*

Ships with service notation **ore carrier ESP** are to be fitted with an enclosed forecastle on the freeboard deck.

The required dimensions of the forecastle are defined in [7.1.2].

The structural arrangements and scantlings of the forecastle are to comply with the requirements in Pt B, Ch 10, Sec 2.

7.1.2 Dimensions *(1/7/2006)*

The forecastle is to be located on the freeboard deck with its aft bulkhead fitted in way or aft of the forward bulkhead of the foremost hold, as shown in Fig 9.

However, if this requirement hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided that the forecastle length aft FE is not less than $0{,}07L_{LL}$, where:

FE : Fore end of the length L, as defined in Pt B, Ch 1, Sec 2, [3.3.1]

L_{LL} : Freeboard length, as defined in Pt B, Ch 1, Sec 2, [3.2]

The forecastle height H_F above the main deck is to be not less than the greater of:

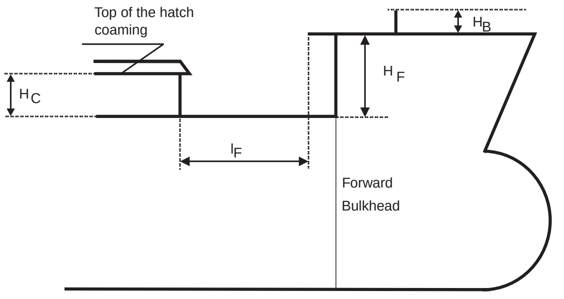
- the standard height of a superstructure, as specified in Pt B, Ch 1, Sec 2, Tab 2, or
- H_C + 0,5 m, where H_C is the height of the forward transverse hatch coaming of cargo hold No.1,

All points of the aft edge of the forecastle deck are to be located at a distance l_F, in compliance with the following formula, from the hatch coaming plate in order to apply the reduced loading to the No.1 forward transverse hatch coaming and No.1 hatch cover in applying Pt B, Ch 9, Sec 7, [3.3.2] and Pt B, Ch 9, Sec 7, [7.2.3], respectively:

$$l_F \le 5\sqrt{H_F - H_C}$$

A breakwater may not be fitted on the forecastle deck with the purpose of protecting the hatch coaming or hatch covers. If fitted for other purposes, it is to be located such that its upper edge at centreline is not less than H_B / tan 20° forward of the aft edge of the forecastle deck, where H_B is the height of the breakwater above the forecastle (see Fig 9).

Figure 9 : Forecastle arrangement *(1/1/2004)*



8 Protection of hull metallic structures

8.1 Protection of sea water ballast tanks

8.1.1 *All dedicated seawater ballast tanks are to have an efficient corrosion prevention system, such as hard protective coatings or equivalent.*

The coatings are preferably to be of a light colour, i.e. a colour easily distinguishable from rust which facilitates inspection.

Where appropriate, sacrificial anodes may also be used.

9 Construction and testing

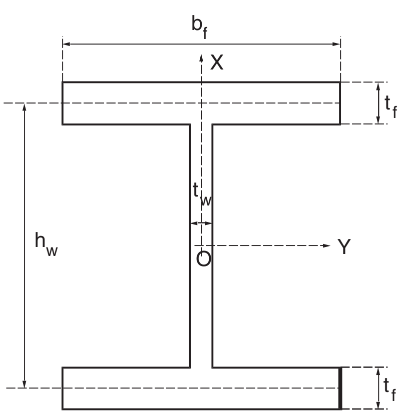
9.1 Welding and weld connections

9.1.1 The welding factors for some hull structural connections are specified in Tab 3. These welding factors are to be used, in lieu of the corresponding factors specified in Pt B, Ch 12, Sec 1, Tab 2, to calculate the throat thickness of fillet weld T connections according to Pt B, Ch 12, Sec 1, [2.3]. For the connections in Tab 3, continuous fillet welding is to be adopted.

9.2 Special structural details

9.2.1 The specific requirements in Pt B, Ch 12, Sec 2, [2.6] for ships with the service notation **ore carrier ESP** are to be complied with.

Table 2 : Calculation of cross-tie geometric properties

Cross-tie profile	e	y_0	J	I_W
T symmetrical 	0	0	$\frac{1}{3}(2b_f t_f^3 + h_w t_w^3)$	$\frac{t_f h_w^2 b_f^3}{24}$

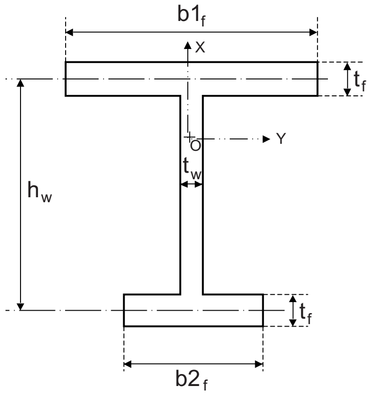
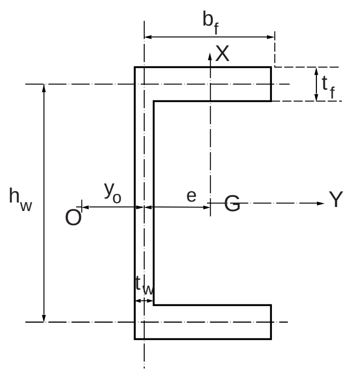
Cross-tie profile	e	y_0	J	I_W
T non-symmetrical 	0	0	$\frac{1}{3}\left[(b_{1f}+b_{2f})t_f^3+h_w t_w^3\right]$	$\frac{t_f h_w^2 b_{1f}^3 b_{2f}^3}{12(b_{1f}^3+b_{2f}^3)}$
Non-symmetrical 	$\frac{b^2 t_f}{h t_w+2bt_f}$	$\frac{3b_f^2 t_f}{6b_f t_f+h_w t_w}$	$\frac{1}{3}(2b_f t_f^3+h_w t_w^3)$	$\frac{t_f b_f^3 h^2}{12}\frac{3b_f t_f+2h_w t_w}{6b_f t_f+h_w t_w}$

Table 3 : Welding factor w_F *(1/7/2002)*

Hull area	Connection			Welding factor w_F
	of	to		
Double bottom in way of cargo holds	girders	bottom and inner bottom plating		0,35
		floors (interrupted girders)		0,35
	floors	bottom and inner bottom plating		0,35
		inner bottom in way of lower stools, in general		0,45
		inner bottom in way of corrugated watertight bulkhead lower stools		Full penetration or partial penetration welding
		girders (interrupted floors)		0,35
Bulkheads in cargo holds	structures of watertight bulkheads	lower stool top plate	plating and ordinary stiffeners (plane bulkheads)	0,45
			vertical corrugations (corrugated bulkheads)	Full penetration welding
		upper stool bottom plate		0,45
		longitudinal bulkheads		0,35
	lower stool structures	boundaries	plating of lower stools, in general	0,45
			plating of lower stools supporting corrugated watertight bulkheads	Full penetration or partial penetration welding
			ordinary stiffeners and diaphragms	0,45
	upper stool structures	boundaries		0,45
	effective shedder plates (see [4.6.7])	vertical corrugations and lower stool top plate		One side penetration welding or equivalent
	effective gusset plates (see [4.6.8])	lower stool top plate		Full penetration welding
		vertical corrugations and shedder plates		One side penetration welding or equivalent

APPENDIX 1 GUIDELINES FOR BALLAST LOADING CONDITIONS OF CARGO VESSELS INVOLVING PARTIALLY FILLED BALLAST TANKS

1 General guidance note

1.1 Introduction

1.1.1 *(1/1/2022)*

This Appendix is intended to provide guidance and interpretation of "Partially filled ballast tanks in ballast loading conditions" in Pt B, Ch 5, Sec 2, [2.1.2] b) and illustrates the conditions (C) necessary for checking longitudinal strength for a conventional ore carrier with two pairs of large wing water ballast tanks partly filled during the ballast voyage.

1.1.2 *(1/1/2022)*

In the Figures, the conditions only intended for strength verification (not operational) are marked with a star (*).

2 Conventional (with usual arrangement of WBT) ore carrier with two pairs of partially filled ballast water tanks

2.1 General

2.1.1 *(1/1/2022)*

Fig 1 show the operational loading conditions, departure condition (C1), four intermediate conditions (C2-C5) and arrival condition (C6), for a conventional (with usual arrangement of WBT) ore carrier with partial filling of both BW tank no.1 (P/S) and 7 (P/S) during voyage.

Table 1 : Filling level in partially filled BW tanks nos.1 (P/S) and 7 (P/S) for the operational conditions during ballast voyage *(1/1/2022)*

Loading condition	Consumables	Filling level, WBT 1(P/S)	Filling level, WBT 7(P/S)
C1 - Departure	100%	f_{1dep}%	f_{7dep}%
C2 – Intermediate 1	50% (1)	f_{1dep}%	f_{7dep}%
C3 – Intermediate 2	50% (1)	f_{1int}%	f_{7int}%
C4 – Intermediate 3	20% (1)	f_{1int}%	f_{7int}%
C5 – Intermediate 4	20% (1)	f_{1arr}%	f_{7arr}%
C6 - Arrival	10%	f_{1arr}%	f_{7arr}%

Note:
(1) % consumables to be specified, indicated to 50% and 20 %

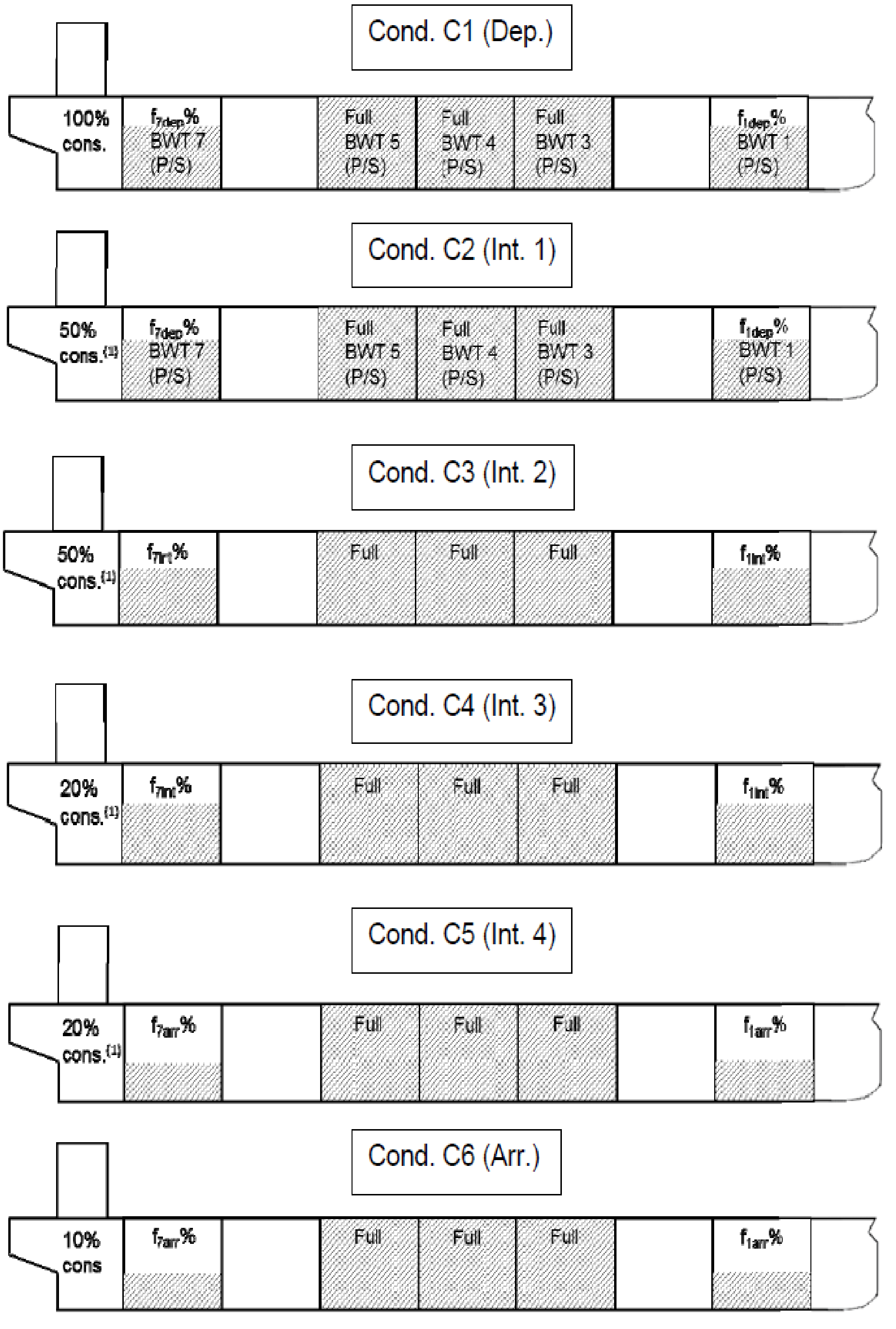
Fig 2 and Fig 3 show the additional twelve loading conditions (C1-1 ~ C1-12) which are to be added for longitudinal strength verification of the departure condition (C1).

Fig 4 and Fig 9 show the additional 32 loading conditions (C2-1 ~ C2-12, C3-1 ~ C3-4, C4-1 ~ C4-12 and C5-1 ~ C5-4) which are to be added for longitudinal strength verification of the intermediate conditions (C2 ~ C5).

Fig 10 and Fig 11 show the additional twelve loading conditions (C6-1 ~ C6-12) which are to be added for longitudinal strength verification of the arrival condition (C6).

For the additional loading conditions, the maximum and the minimum filling level of BW tank are according to trim and propeller immersion limitations given in Pt B, Ch 5, Sec 2, [2.1.2] b).

Figure 1 : *(1/1/2022)*



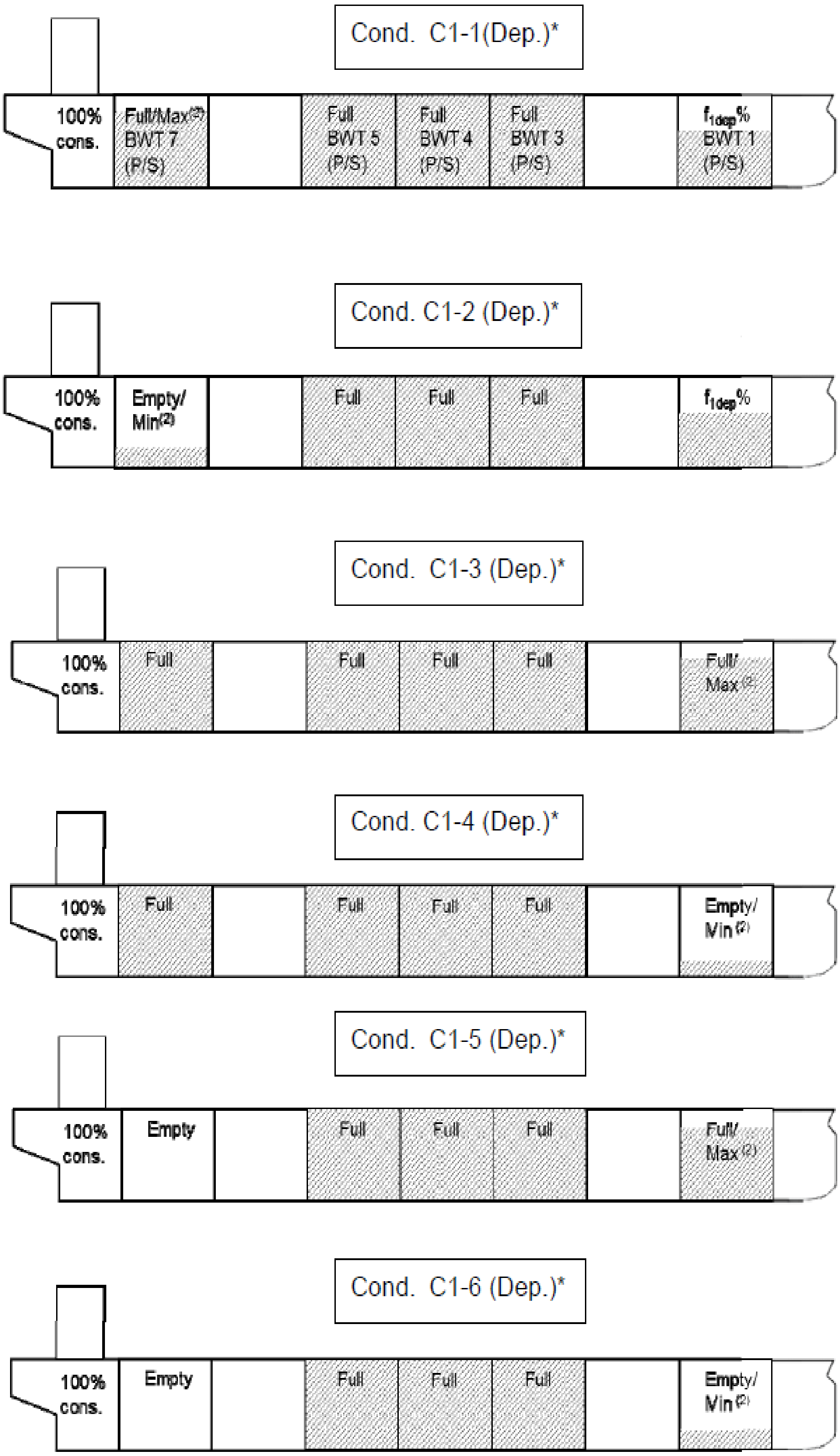
Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during ballast voyage, operational conditions C1-C6.

Notes:

(1) The intermediate condition(s) to be specified incl.% consumables.

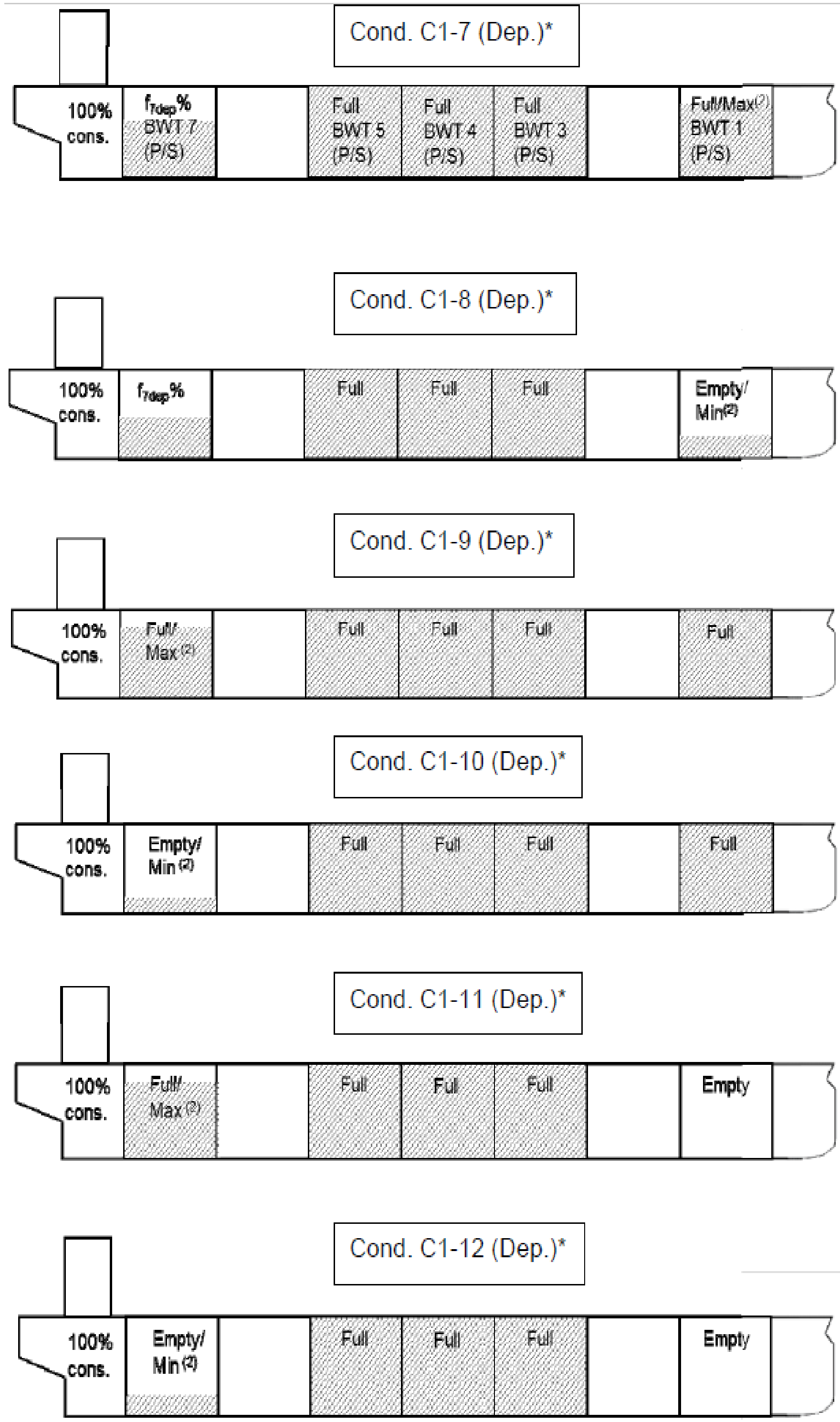
(2) Figures 2-11: Maximum and minimum filling level of BW tank according to trim and propeller immersion limitations given in Pt B, Ch 5, Sec 2, [2.1.2] b).

Figure 2 *(1/1/2022)*



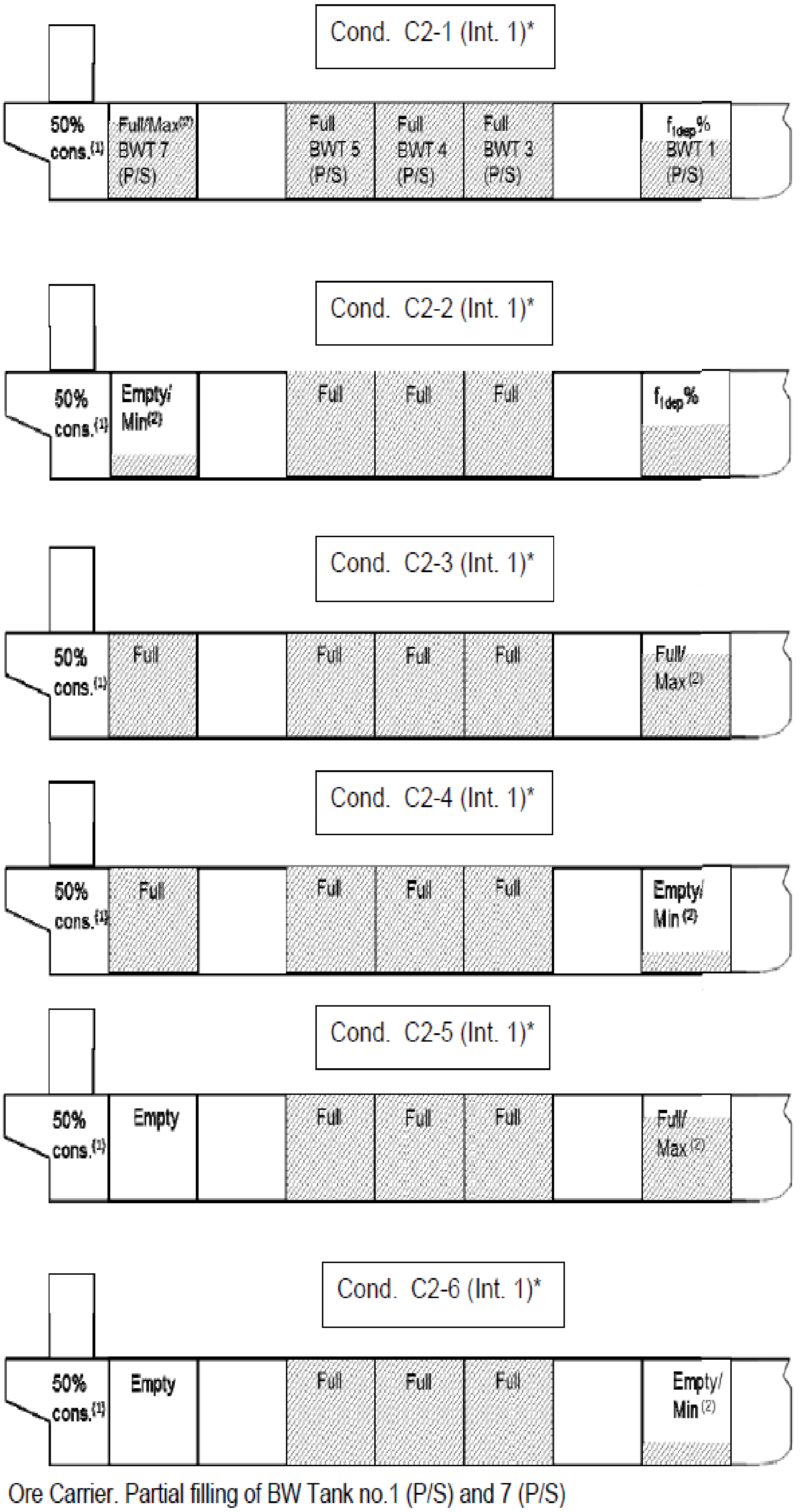
Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during voyage. Departure conditions C1-1~C1-6, only intended for strength verification (not operational) are marked: *

Figure 3 *(1/1/2022)*



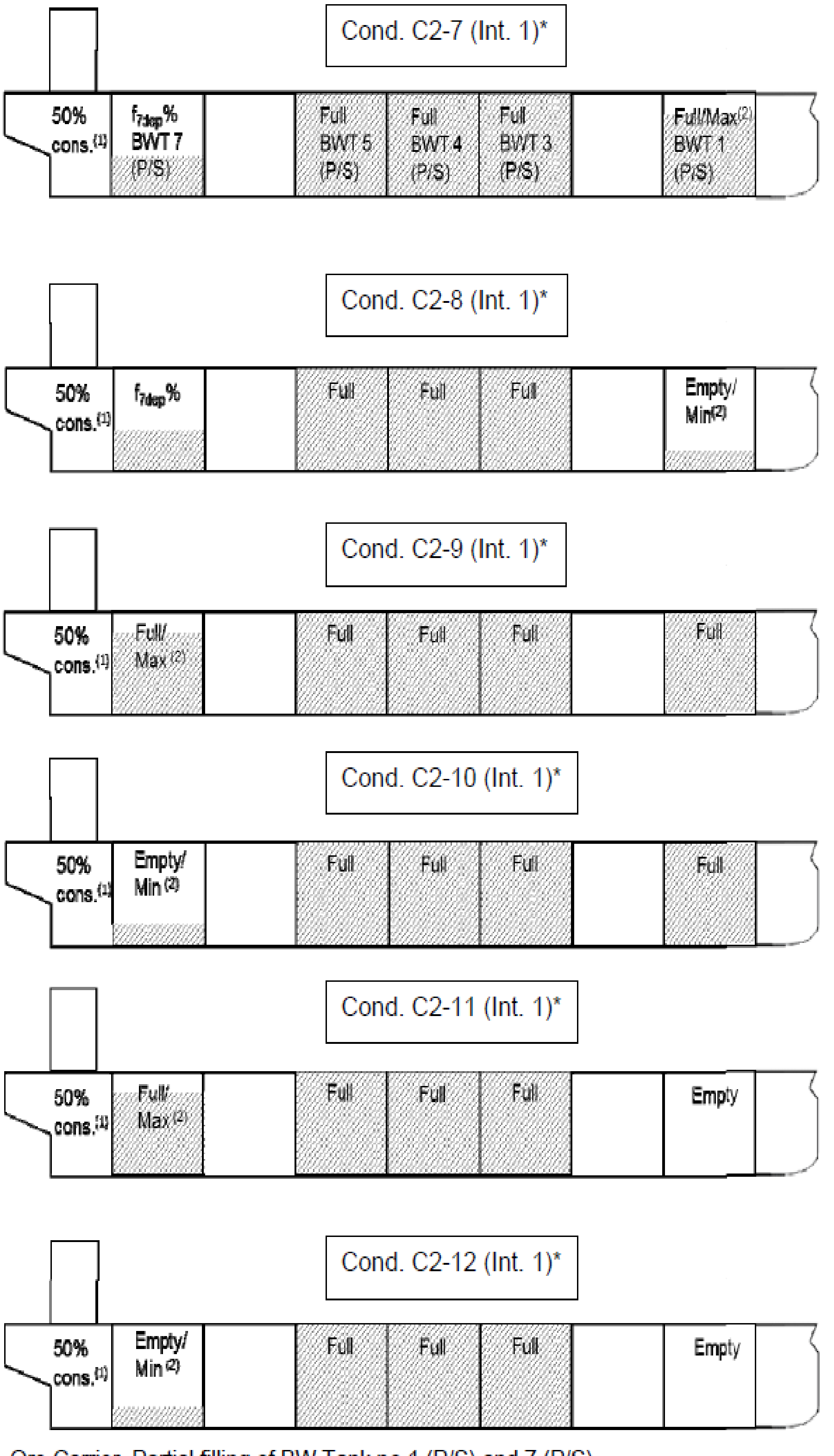
Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during voyage. Departure conditions CD1-7~C1-12, only intended for strength verification (not operational) are marked: *

Figure 4 *(1/1/2022)*



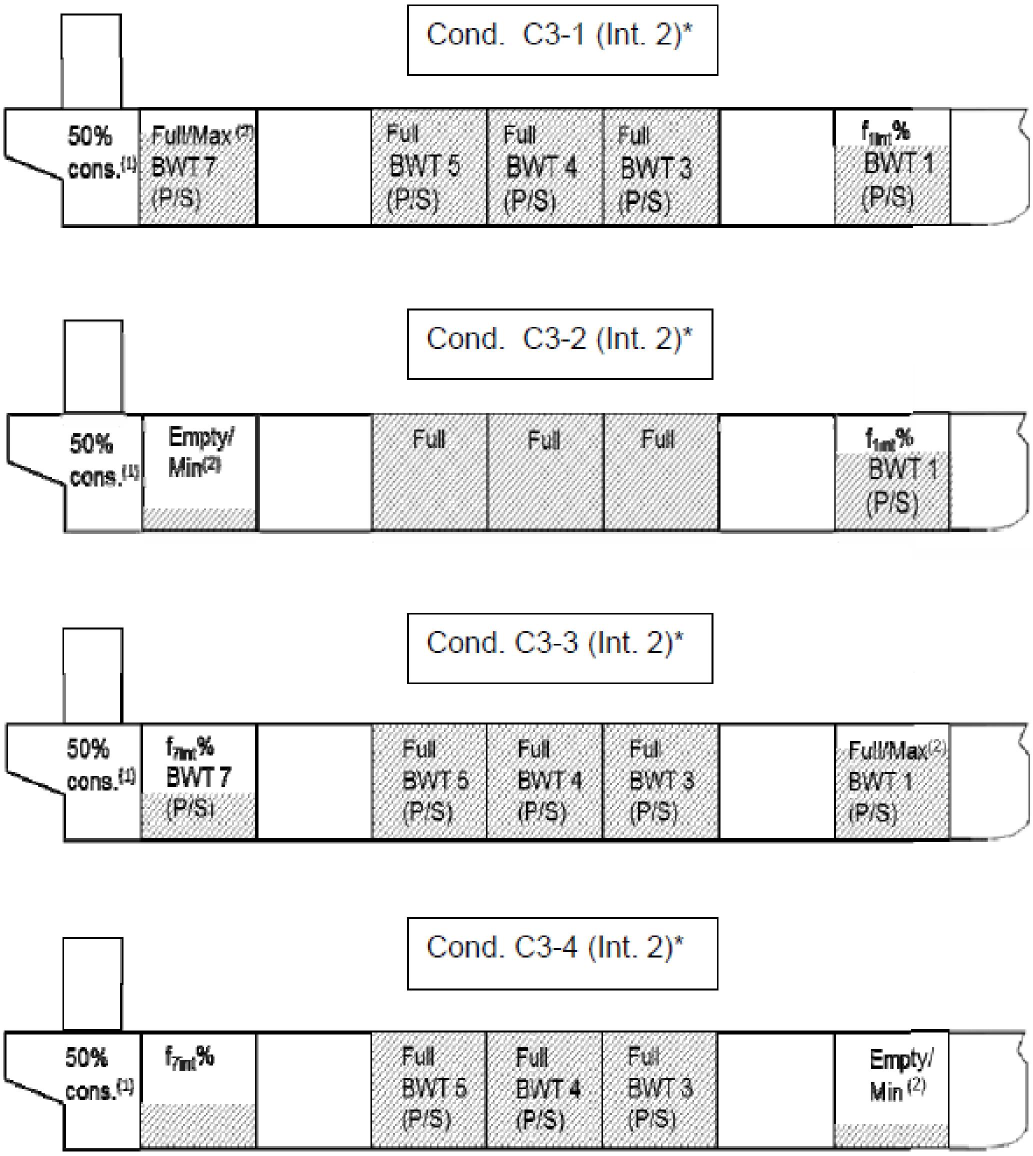
Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during voyage. Intermediate conditions C2-1~C2-6, only intended for strength verification (not operational) are marked: *

Figure 5 *(1/1/2022)*



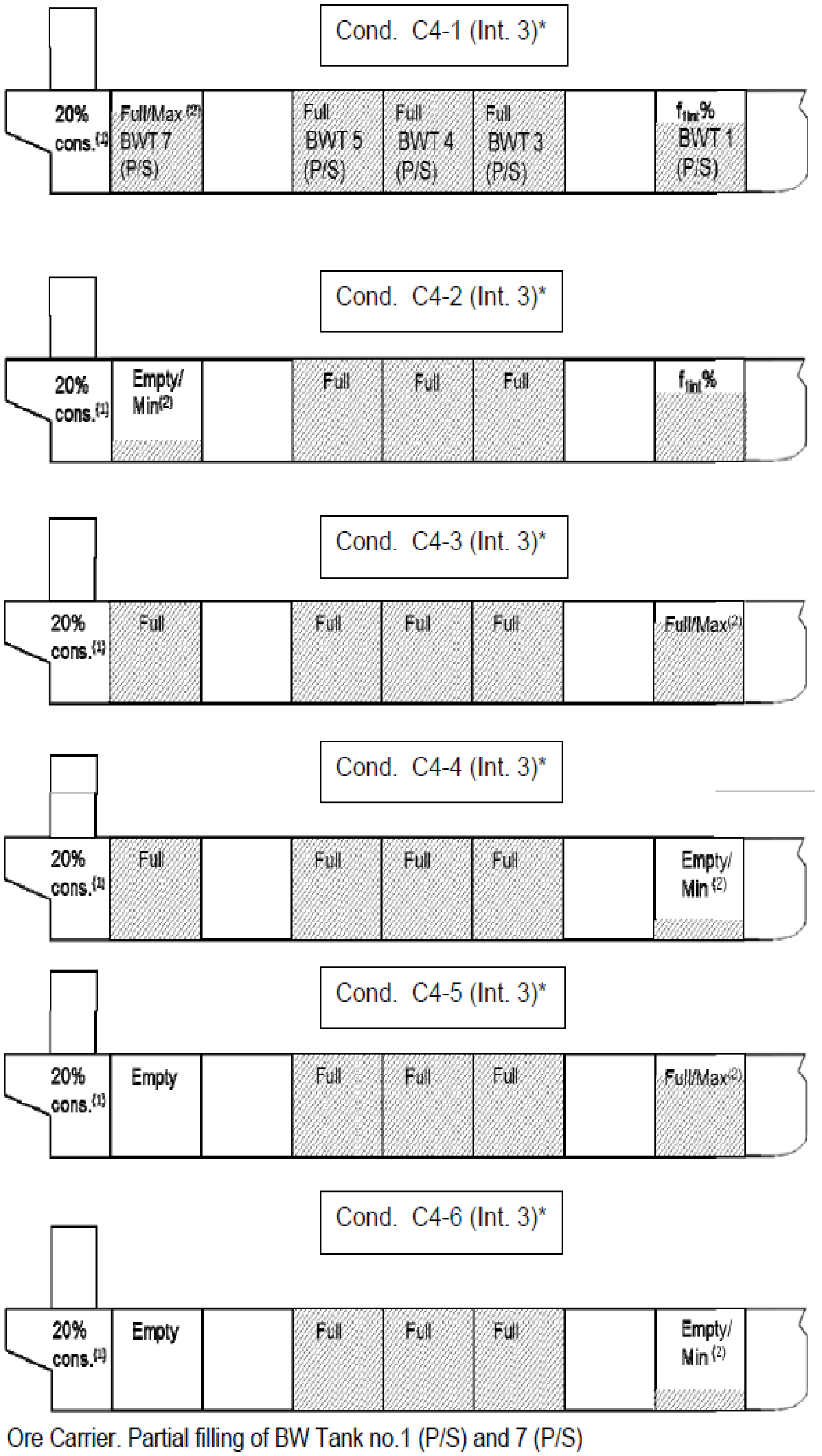
Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during voyage. Intermediate conditions C2-7~C2-12, only intended for strength verification (not operational) are marked: *

Figure 6 *(1/1/2022)*



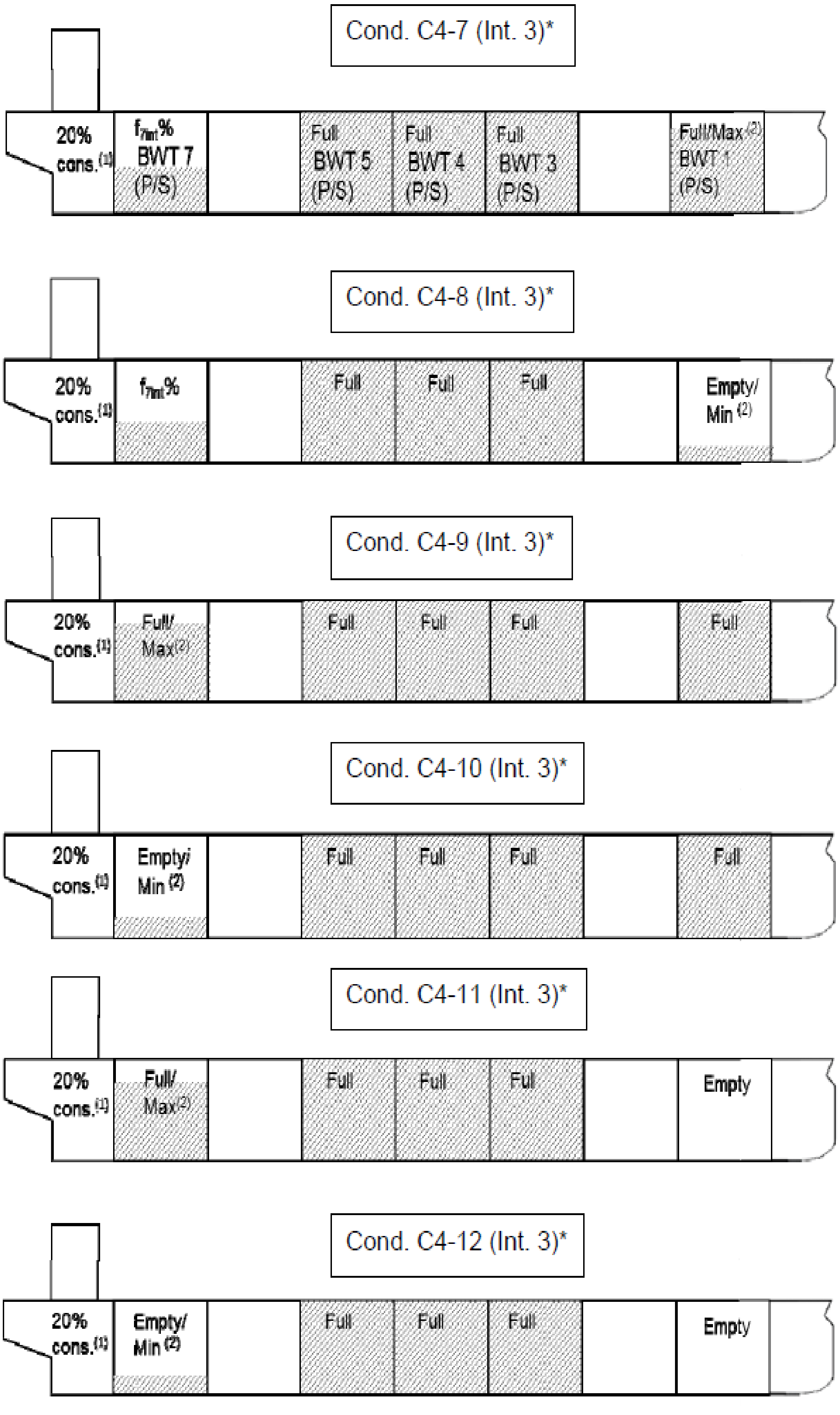
Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during voyage. Intermediate conditions C3-1~C3-4, only intended for strength verification (not operational) are marked: *

Figure 7 *(1/1/2022)*



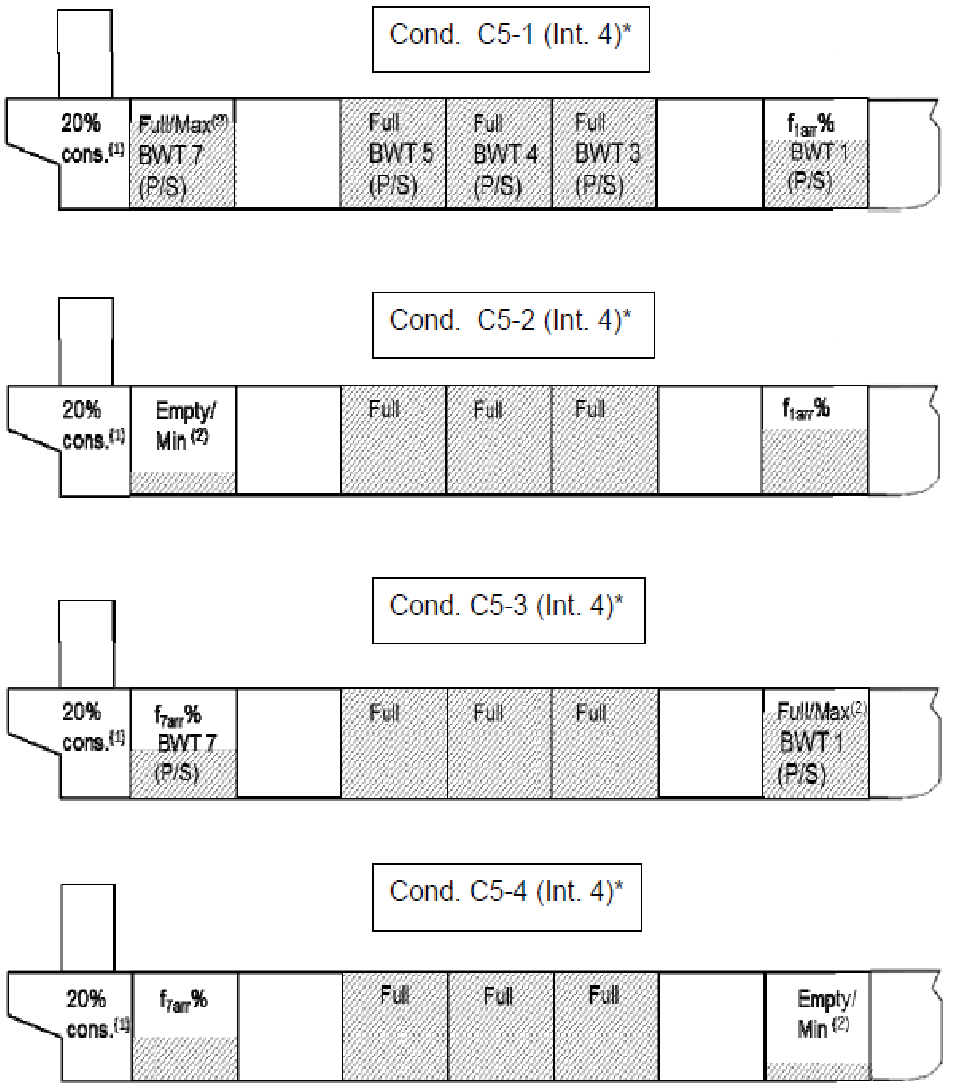
Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during voyage. Intermediate conditions C4-1~C4-6, only intended for strength verification (not operational) are marked: *

Figure 8 *(1/1/2022)*



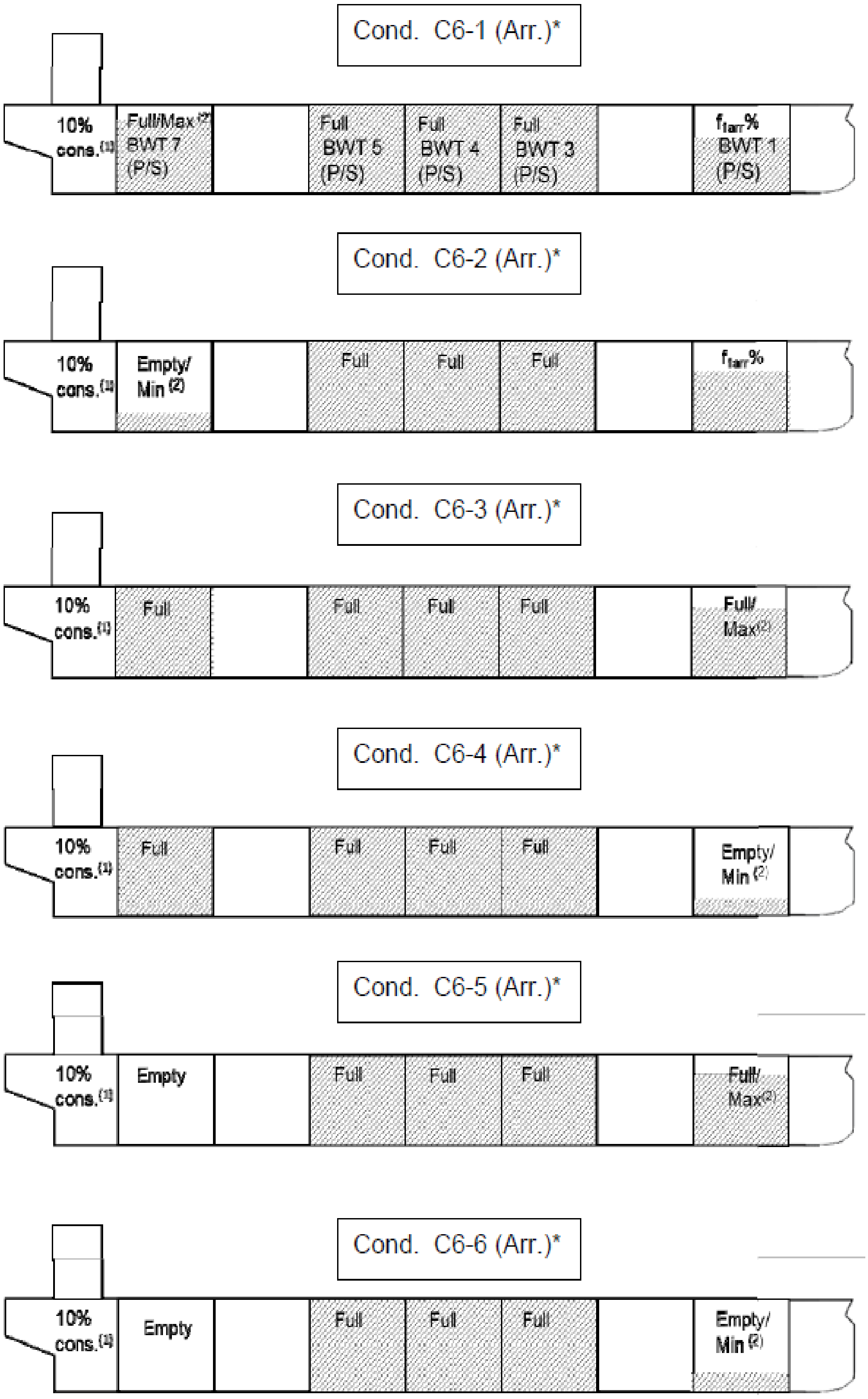
Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during voyage. Intermediate conditions C4-7~C4-12, only intended for strength verification (not operational) are marked: *

Figure 9 *(1/1/2022)*



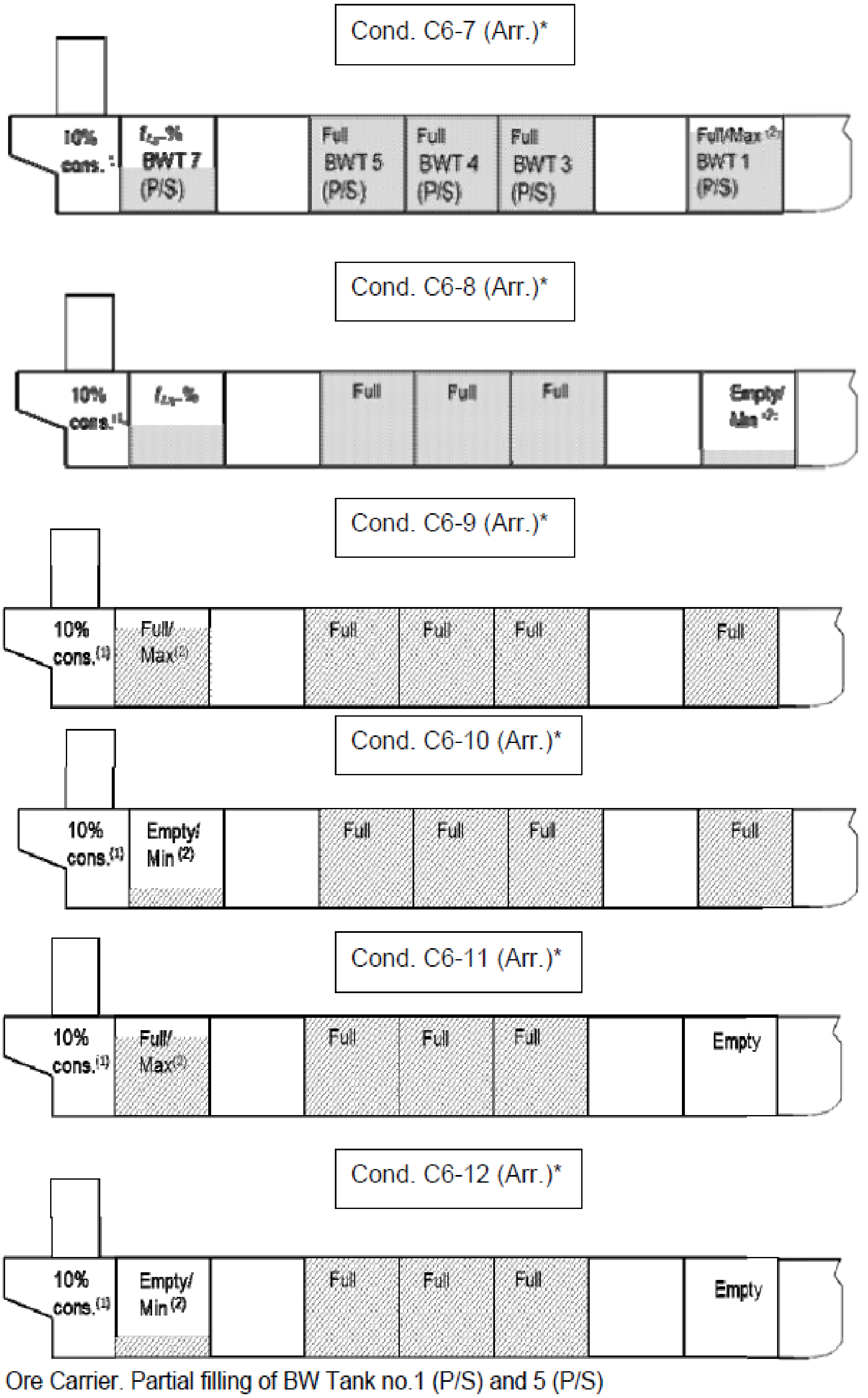
Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during voyage. Intermediate conditions C5-1~C5-4, only intended for strength verification (not operational) are marked: *

Figure 10 *(1/1/2022)*



Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 7 (P/S) during voyage. Arrival conditions C6-1~C6-6, only intended for strength verification (not operational) are marked: *

Figure 11 *(1/1/2022)*



Ore Carrier. Partial filling of BW Tank no.1 (P/S) and 5 (P/S) during voyage. Arrival conditions C6-7~C6-12, only intended for strength verification (not operational) are marked: *

Part E
Service Notations

Chapter 6
COMBINATION CARRIERS

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 Ships complying with the requirements of this Chapter are eligible for the assignment of the service notation **combination carrier**, as defined in Pt A, Ch 1, Sec 2, [4.3.6] and Pt A, Ch 1, Sec 2, [4.3.7].

1.1.2 Ships dealt with in this Chapter are to comply with the requirements stipulated in Part A, Part B, Part C and Part D, as applicable, and with the requirements of this Chapter, which are specific to combination carriers.

1.2 Summary table

1.2.1 Tab 1 indicates, for easy reference, the Sections of this Chapter dealing with requirements applicable to combination carriers.

Table 1

Main subject	Reference
Ship arrangement	Sec 2
Hull and stability	Sec 3
Machinery and cargo system	Sec 4
Electrical installations	**(1)**
Automation	**(1)**
Fire protection, detection and extinction	**(2)**

(1) No specific requirements for combination carriers are given in this Chapter.
(2) The specific requirements for combination carriers are given in Part C, Chapter 4.

SECTION 2 SHIP ARRANGEMENT

1 General

1.1 Application

1.1.1 The requirements in Sec 2 and Sec 3 apply to:

- single deck ships of double side skin construction, with a double bottom, hopper tanks and topside tanks and intended to carry dry cargoes in bulk, including ore cargo, or oil cargoes in bulk (ships with the service notation **combination carrier/OBO ESP**); a typical midship section is shown in Fig 1
- single deck ships with two longitudinal bulkheads and a double bottom throughout the cargo region and intended to carry dry cargoes in bulk, including ore cargo, or oil cargoes in the centre holds (ships with the service notation **combination carrier/OOC ESP**); typical midship sections are shown in Fig 2.

The application of these requirements to other ship types is to be considered by the Society on a case-by-case basis.

2 General arrangement design

2.1 General

2.1.1 Cofferdams

A cofferdam or similar compartment of width not less than 760 mm is to be provided at the aft end of the oil cargo tank area. Its bulkheads are to extend from keel to deck across the full breadth of the ship.

For the purpose of this requirement, the term “cofferdam” is intended to mean an isolating compartment between two adjacent steel bulkheads or decks. The minimum distance between the two bulkheads or decks is to be sufficient for safe access and inspection.

In order to meet the single failure principle, in the particular case when a corner-to-corner situation occurs, this principle may be met by welding a diagonal plate across the corner.

Cofferdams are also to be constructed so as to enable adequate ventilation.

2.1.2 Cargo segregation

Unless expressly provided otherwise, tanks containing oil cargoes or oil cargo residues are to be segregated from accommodation, service and machinery spaces, drinking water and stores for human consumption by means of a cofferdam, or any other similar compartment.

Where accommodation and service compartments are arranged immediately above the compartments containing flammable liquids, the cofferdam may be omitted only where the deck is not provided with access openings and is coated with a layer of material recognised as suitable by the Society. The cofferdam may also be omitted where such compartments are adjacent to a passageway, subject to the following conditions:

- the thicknesses of common boundary plates of adjacent tanks are increased with respect to those obtained from the applicable requirements in Pt B, Ch 6, Sec 2, 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 such plates is not less than the thickness of the plates themselves
- the hydrostatic test is carried out with a head increased by 1 m with respect to that required in Pt B, Ch 12, Sec 3.

Figure 1 : combination carrier/OBO

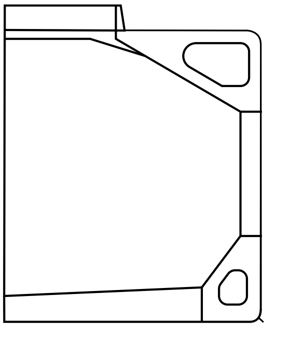
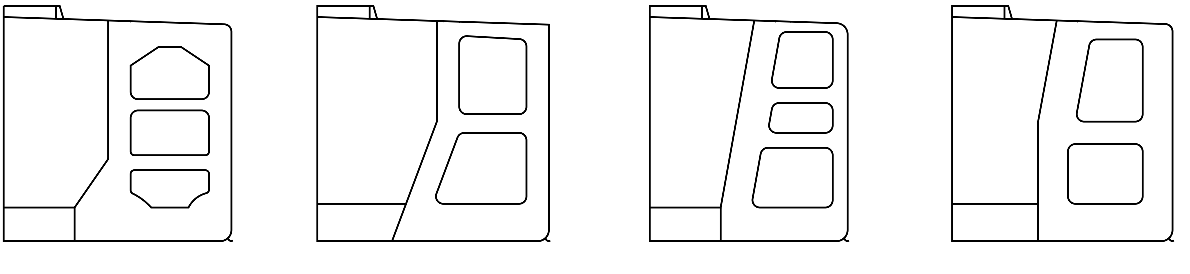


Figure 2 : combination carrier/OOC



Combination carriers of 600 t deadweight and above are not allowed to carry oil in any compartment extending forward of a collision bulkhead located in accordance with Pt B, Ch 2, Sec 1, [2].

2.1.3 Slop tanks

The slop tanks are to be surrounded by cofferdams except where the boundaries of the slop tanks where slop may be carried on dry cargo voyages are the hull, main cargo deck, cargo pump room bulkhead or fuel oil bunker tank. These cofferdams are to be not open to a double bottom, pipe tunnel, pump room or other enclosed space.

Means are to be provided for filling the cofferdams with water and for draining them.

Where the boundary of a slop tank is the cargo pump room bulkhead, the pump room is to be not open to the double bottom, pipe tunnel or other enclosed space; however, openings provided with gas-tight bolted covers may be permitted.

2.1.4 Deck spills

Means are to be provided to keep deck spills away from the accommodation and service areas. This may be accomplished by providing a permanent continuous coaming of a suitable height extending from side to side.

Where gutter bars are installed on the weather decks of combination carriers in way of cargo manifolds and are extended aft as far as the aft bulkhead of superstructures for the purpose of containing cargo spills on deck during loading and discharge operations, the free surface effects caused by containment of a cargo spill during liquid transfer operations or of boarding seas while underway are to be considered with respect to the vessel's available margin of positive initial stability (GM_o).

Where the gutter bars installed are higher than 300 mm, they are to be treated as bulwarks with freeing ports arranged in accordance with Pt B, Ch 9, Sec 9, [5] and provided with effective closures for use during loading and discharge operations. Attached closures are to be arranged in such a way that jamming cannot occur while at sea, ensuring that the freeing ports will remain fully effective.

On ships without deck camber, or where the height of the installed gutter bars exceeds the camber, and for combination carriers having cargo tanks exceeding 60% of the vessel's maximum beam amidships regardless of gutter bar height, gutter bars may not be accepted without an assessment of the initial stability (GM_o) for compliance with the relevant intact stability requirements taking into account the free surface effect caused by liquids contained by the gutter bars.

2.1.5 Piping

Means are to be provided for isolating the piping connecting the pump room with the slop tanks. The means of isolation are to consist of a valve followed by a spectacle flange or a spool piece with appropriate blank flanges.

This arrangement is to be located adjacent to the slop tanks, but where this is unreasonable or impracticable it may be located within the pump room directly after the piping penetrates the bulkhead.

A separate pumping and piping arrangement is to be provided for discharging the contents of the slop tanks directly over the open deck when the ship is in the dry cargo mode.

Oil cargo lines below deck are to be placed in special ducts.

2.1.6 Opening in watertight bulkheads and decks

Openings intended to be used for dry cargo handling are not permitted in bulkheads and decks separating oil cargo tanks from other compartments not designed and equipped for the carriage of oil cargoes unless such openings are equipped with alternative means approved by the Society to ensure an equivalent integrity.

2.1.7 Tank cleaning openings

Hatches and tank cleaning openings to slop tanks are only permitted on the open deck and are to be fitted with closing arrangements.

Except where they consist of bolted plates with bolts at watertight spacing, these closing arrangements are to be provided with locking arrangements which are to be under the control of the responsible ship's officer.

2.2 Double bottom tanks or compartments

2.2.1 General

Double bottom tanks adjacent to cargo tanks may not be used as fuel oil tanks.

2.2.2 Combination carriers of 5000 t deadweight and above *(1/7/2007)*

At any cross-section, the depth of each double bottom tank or compartment is to be such that the distance h between the bottom of the cargo tanks and the moulded line of the bottom shell plating measured at right angles to the bottom shell plating, as shown in Fig 3, is not less than B/15, in m, or 2,0 m, whichever is the lesser. h is to be not less than 1,0 m.

Any horizontal partition necessary to fulfil the above requirements is to be located at a height not less than B/6 or 6 m, whichever is the lesser, but not more than 0,6D, above the baseline where D is the moulded depth amidships.

2.2.3 Combination carriers of less than 5000 t but at least 600 t deadweight

At any cross-section, the depth of each double bottom tank or compartment is to be such that the distance h between the bottom of the cargo tanks and the moulded line of the bottom shell plating measured at right angles to the bottom shell is not less than B/15, in m, with a minimum value of 0,76 m.

In the turn of the bilge area and at locations without a clearly defined turn of the bilge, the cargo tank boundary line is to run parallel to the line of the midship flat bottom as shown in Fig 4.

Figure 3 : Cargo tank boundary lines

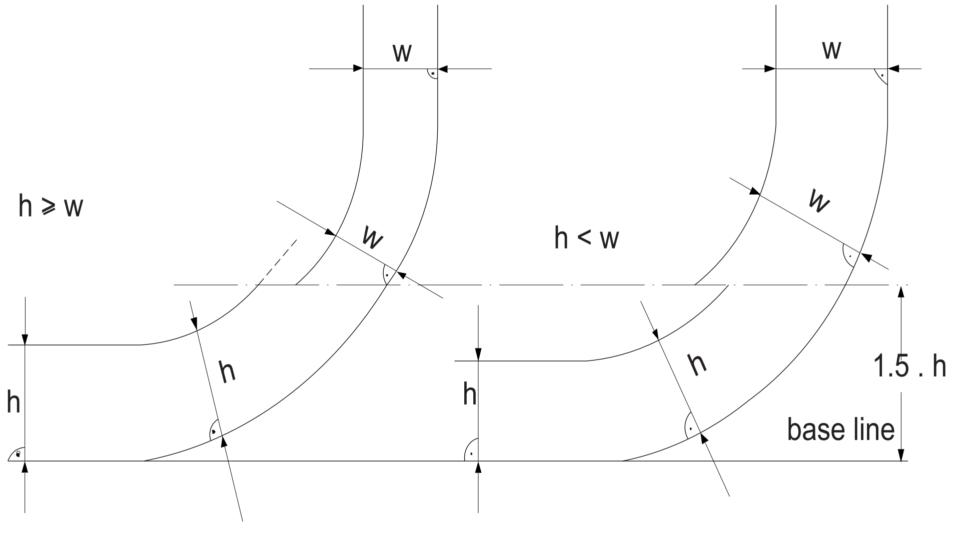
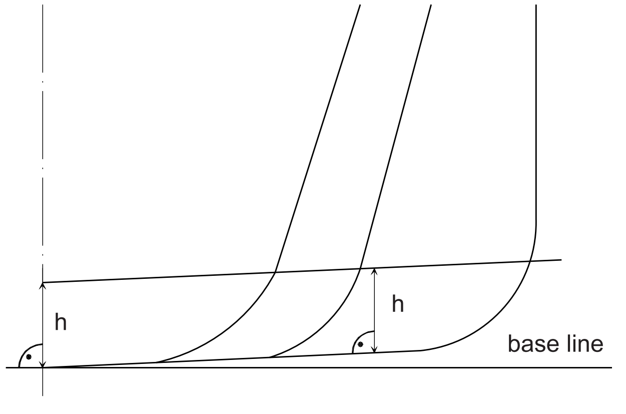


Figure 4 : Cargo tank boundary lines



2.3 Navigation position

2.3.1 When it is proven necessary to provide a navigation station above the cargo area, such station is to be for navigation purposes only and is to be separated from the cargo tank deck by an open space of at least 2 m in height.

3 Size and arrangement of cargo tanks and slop tanks

3.1 Cargo tanks

3.1.1 Combination carriers of 5000 t deadweight and above *(1/7/2007)*

Combination carriers of 5000 t deadweight and above are to comply with the requirements in [3.2].

3.1.2 Combination carriers of less than 5000 t but at least 600 t deadweight *(1/7/2007)*

The length of each cargo tank is not to exceed 10 metres or one of the values of Tab 1, as applicable, whichever is the greater.

3.1.3 Piping through cargo tanks *(1/7/2007)*

Lines of piping which run through oil cargo tanks in a position less than 0,30 B_S from the ship side or less than 0,30 D_S from the ship's bottom are to be fitted with valves or similar closing devices at the point at which they open into any cargo tank. These valves are to be kept closed at sea at any time when the tanks contain cargo oil, except that they may be opened only for cargo transfer needed for essential operations.

Table 1 : Length of cargo tanks

Longitudinal bulkhead arrangement	Condition **(1)**	Length of cargo tanks, in m
No bulkhead (**combination carrier/OBO ESP**)	-	(0,5 b_i / B + 0,1) L **(2)**
Two bulkheads (**combination carrier/OOC ESP**)	b_i / B ≥ 1/5	0,2 L
	b_i / B < 1/5	(0,5 b_i / B + 0,1) L

(1) b_i is the minimum distance from the ship side to the outer longitudinal bulkhead of the i-th tank, measured inboard at right angles to the centreline at the level corresponding to the assigned summer freeboard.
(2) Not to exceed 0,2 L.

3.1.4 Suction wells in cargo tanks

Suction wells in cargo tanks may protrude into the double bottom below the boundary line defined by the distance h in [2.2.2] or [2.2.3], as applicable, provided that such wells are as small as practicable and the distance between the well bottom and bottom shell plating is not less than 0,5 h.

3.2 Oil outflow

3.2.1 Definitions *(1/7/2007)*

- *Load line draught d_S, in m*

  Vertical distance, in metres, from the moulded baseline at mid-length to the waterline corresponding to the summer freeboard to be assigned to the ship. Calculations pertaining to this requirement are to be based on draught d_S, notwithstanding assigned draughts that may exceed d_S, such as the tropical load line.

- *Waterline d_B, in m*

  Vertical distance, in metres, from the moulded baseline at mid-length to the waterline corresponding to 30% of the depth D_S.

- *Breadth B_S, in m*

  Greatest moulded breadth of the ship, in metres, at or below the deepest load line d_S.

- *Breadth B_B, in m*

  Greatest moulded breadth of the ship, in metres, at or below the waterline d_B.

- *Depth D_S, in m*

  Moulded depth measured at mid-length to the upper deck at side.

In calculating the hypothetical oil outflows, the following is to be considered:

- *the volume of an oil cargo tank is to include the volume of the hatchway up to the top of the hatchway coamings, regardless of the construction of the hatch, but may not include the volume of any hatch cover; and*
- *for the measurement of the volume to moulded lines, no deduction is to be made for the volume of internal structures.*

3.2.2 Oil outflow requirements *(1/7/2007)*

To provide adequate protection against oil pollution in the event of collision or stranding, the following is to be complied with:

a) *for oil tankers of 5000 tonnes deadweight (DW) and above, the mean oil outflow parameter is to be as follows:*

   $O_M \leq 0,015$ for $C \leq 200000$ m^3

   $O_M \leq 0,012 + (0,003/200000)(400000-C)$ for 200000 m^3 $< C < 400000$ m^3

   $O_M \leq 0,012$ for $C \geq 400000$ m^3

b) *for combination carriers between 5000 tonnes deadweight (DW) and 200000 m^3 capacity, the mean oil outflow parameter may be applied, provided calculations are submitted to the satisfaction of the Society, demonstrating that after accounting for its increased structural strength, the combination carrier has at least equivalent oil outflow performance to a standard double hull tanker of the same size having a $O_M \leq 0,015$.*

   $O_M \leq 0,021$ for $C \leq 100000$ m^3

   $O_M \leq 0,015 + (0,006/100000)(200000-C)$ for 100000 m^3 $< C \leq 200000$ m^3

where:

O_M : *mean oil outflow parameter.*

C : *total volume of cargo oil, in m^3, at 98% tank filling.*

3.2.3 General assumptions for calculation of oil outflow parameter *(1/7/2007)*

The following general assumptions are to be applied when calculating the mean oil outflow parameter:

a) *The cargo block length extends between the forward and aft extremities of all tanks arranged for the carriage of cargo oil, including slop tanks.*

b) *Where this requirement refers to cargo tanks, it is to be understood to include all cargo tanks, slop tanks and fuel tanks located within the cargo block length.*

c) *The ship is to be assumed loaded to the load line draught d_S without trim or heel.*

d) *All cargo oil tanks are to be assumed loaded to 98% of their volumetric capacity.*

e) *The nominal density of the cargo oil ρ_n, in kg/m^3, is to be calculated as follows:*

   $\rho_n = 1000\ DW / C$

   where DW is deadweight, in t.

f) *For the purposes of these outflow calculations, the permeability of each space within the cargo block, including cargo tanks, ballast tanks and other non-oil spaces, is to be taken as 0,99, unless proven otherwise.*

g) *Suction wells may be neglected in the determination of tank location provided that such wells are as small as practicable and the distance between the well bottom and bottom shell plating is not less than 0,5 h, where h is the height as defined in [2.2.2].*

3.2.4 General assumptions for combination of oil outflow parameters *(1/7/2007)*

The following assumptions are to be used when combining the oil outflow parameters.

The mean oil outflow is to be calculated independently for side damage and for bottom damage and then combined into the non-dimensional oil outflow parameter O_M, as follows:

$O_M = (0,4\ O_{MS} + 0,6\ O_{MB}) / C$

where:

O_{MS} : *mean outflow for side damage, in m^3;*

O_{MB} : *mean outflow for bottom damage, in m^3.*

For bottom damage, independent calculations for mean outflow are to be done for 0 m and minus 2,5 m tide conditions, and then combined as follows:

$O_{MB} = 0,7\ O_{MB(0)} + 0,3\ O_{MB(2,5)}$

where:

$O_{MB(0)}$: *mean outflow for 0 m tide condition, in m^3; and*

$O_{MB(2,5)}$: *mean outflow for minus 2,5 m tide condition, in m^3.*

3.2.5 Calculation of side damage outflow *(1/7/2007)*

The mean outflow for side damage O_{MS}, in m^3, is to be calculated as follows:

$$O_{MS} = C_3 \sum_{i}^{n} P_{s(i)} O_{s(i)}$$

where:

i : *represents each cargo tank under consideration;*

n : *total number of cargo tanks;*

$P_{S(i)}$: *the probability of penetrating cargo tank i from side damage, calculated in accordance with [3.2.7];*

$O_{S(i)}$: *the outflow, in m³, from side damage to cargo tank i, which is assumed equal to the total volume in cargo tank i at 98% filling, unless it is proven through the application of the IMO Resolution referred to in [4.2.5] that any significant cargo volume will be retained;*

C_3 : *0,77 for ships having two longitudinal bulkheads inside the cargo tanks, provided these bulkheads are continuous over the cargo block and $P_{s(i)}$ is developed in accordance with this requirement. C_3 equals 1,0 for all other ships or when $P_{s(i)}$ is developed in accordance with [3.2.7].*

3.2.6 Calculation of bottom damage outflow *(1/7/2007)*

The mean outflow for bottom damage, in m³, is to be calculated for each tidal condition as follows:

a)

$$O_{MB(0)} = \sum_i^n P_{B(i)} O_{B(i)} C_{DB(i)}$$

where:

i : *represents each cargo tank under consideration;*

n : *total number of cargo tanks;*

$P_{B(i)}$: *the probability of penetrating cargo tank i from bottom damage, calculated in accordance with [3.2.8];*

$O_{B(i)}$: *the outflow from cargo tank i, in m³, calculated in accordance with c);*

$C_{DB(i)}$: *factor to account for oil capture as defined in d).*

b)

$$O_{MB(2,5)} = \sum_i^n P_{B(i)} O_{B(i)} C_{DB(i)}$$

where:

i, n, $P_{B(i)}$ and $C_{DB(i)}$ as defined above;

$O_{B(i)}$: *the outflow from cargo tank i, in m³, after tidal change.*

c) The oil outflow $O_{B(i)}$ for each cargo oil tank is to be calculated based on pressure balance principles, in accordance with the following assumptions:

- *The ship is to be assumed stranded with zero trim and heel, with the stranded draught prior to tidal change equal to the load line draught d_s.*
- *The cargo level after damage is to be calculated as follows:*

  $h_c = [(d_s + t_c - Z_l)(\rho_s) - (1000\ p) / g] / \rho_n$

  where:

  h_c : *the height of the cargo oil above Z_l, in metres;*

  t_c : *the tidal change, in m. Reductions in tide are to be expressed as negative values;*

  Z_l : *the height of the lowest point in the cargo tank above the baseline, in m;*

  ρ_s : *density of seawater, to be taken as 1025 kg/m³;*

  p : *if an inert gas system is fitted, the normal overpressure, in kPa, to be taken not less than 5 kPa; if an inert gas system is not fitted, the overpressure may be taken as 0;*

  g : *the acceleration of gravity, to be taken as 9,81 m/s²;*

  ρ_n : *nominal density of cargo oil, calculated in accordance with [3.2.3].*

- *For cargo tanks bounded by the bottom shell, unless proven otherwise, oil outflow $O_{B(i)}$ is to be taken not less than 1% of the total volume of cargo oil loaded in cargo tank i, to account for initial exchange losses and dynamic effects due to current and waves.*

d) In the case of bottom damage, a portion from the outflow from a cargo tank may be captured by non-oil compartments. This effect is approximated by application of the factor $C_{DB(i)}$ for each tank, which is to be taken as follows:

$C_{DB(i)}$: *0,6 for cargo tanks bounded from below by non-oil compartments;*

$C_{DB(i)}$: *1,0 for cargo tanks bounded by the bottom shell.*

3.2.7 Calculation of probability for side damage *(1/7/2007)*

The probability P_S of breaching a compartment from side damage is to be calculated as follows:

a) $P_S = P_{SL}\ P_{SV}\ P_{ST}$

where:

$P_{SL} = 1 - P_{Sf} - P_{Sa}$ = probability the damage will extend into the longitudinal zone bounded by X_a and X_f;

$P_{SV} = 1 - P_{Su} - P_{Sl}$ = probability the damage will extend into the vertical zone bounded by Z_l and Z_u; and

$P_{ST} = 1 - P_{Sy}$ = probability the damage will extend transversely beyond the boundary defined by y.

b) P_{Sa}, P_{Sf}, P_{Sl}, P_{Su} and P_{Sy} are to be determined by linear interpolation from the table of probabilities for side damage provided in Tab 2,

where:

P_{Sa} : *the probability the damage will lie entirely aft of location X_a/L;*

P_{Sf} : *the probability the damage will lie entirely forward of location X_f/L;*

P_{Sl} : *the probability the damage will lie entirely below the tank;*

P_{Su} : *the probability the damage will lie entirely above the tank; and*

P_{Sy} : *the probability the damage will lie entirely outboard of the tank.*

Compartment boundaries X_a, X_f, Z_l, Z_u and y are to be developed as follows:

X_a : *the longitudinal distance from the aft terminal of L to the aftmost point on the compartment being considered, in m;*

X_f : *the longitudinal distance from the aft terminal of L to the foremost point on the compartment being considered, in m;*

Z_l : *the vertical distance from the moulded baseline to the lowest point on the compartment being considered, in m;*

Z_u : *the vertical distance from the moulded baseline to the highest point on the compartment being considered, in m. Z_u is not to be taken greater than D_s;*

y : *the minimum horizontal distance measured at right angles to the centreline between the compartment under consideration and the side shell in m;*

c) *P_{Sy} is to be calculated as follows:*

$P_{Sy} = (24{,}96 - 199{,}6\ y/B_S)\ (y/B_S)$ *for* $y/B_S \leq 0{,}05$

$P_{Sy} = 0{,}749 + [5 - 44{,}4\ (y/B_S - 0{,}05)]\ (y/B_S - 0{,}05)$ *for* $0{,}05 < y/B_S < 0{,}1$

$P_{Sy} = 0{,}888 + 0{,}56\ (y/B_S - 0{,}1)$ *for* $y/B_S > 0{,}1$

P_{Sy} is not to be taken greater than 1.

Table 2 : Probabilities for side damage *(1/7/2007)*

X_a/L	P_{Sa}	X_f/L	P_{Sf}	Z_l/D_S	P_{Sl}	Z_u/D_S	P_{Su}
0,00	0,000	0,00	0,967	0,00	0,000	0,00	0,968
0,05	0,023	0,05	0,917	0,05	0,000	0,05	0,952
0,10	0,068	0,10	0,867	0,10	0,001	0,10	0,931
0,15	0,117	0,15	0,817	0,15	0,003	0,15	0,905
0,20	0,167	0,20	0,767	0,20	0,007	0,20	0,873
0,25	0,217	0,25	0,717	0,25	0,013	0,25	0,836
0,30	0,267	0,30	0,667	0,30	0,021	0,30	0,789
0,35	0,317	0,35	0,617	0,35	0,034	0,35	0,733
0,40	0,367	0,40	0,567	0,40	0,055	0,40	0,670
0,45	0,417	0,45	0,517	0,45	0,085	0,45	0,599
0,50	0,467	0,50	0,467	0,50	0,123	0,50	0,525
0,55	0,517	0,55	0,417	0,55	0,172	0,55	0,452
0,60	0,567	0,60	0,367	0,60	0,226	0,60	0,383
0,65	0,617	0,65	0,317	0,65	0,285	0,65	0,317
0,70	0,667	0,70	0,267	0,70	0,347	0,70	0,255
0,75	0,717	0,75	0,217	0,75	0,413	0,75	0,197
0,80	0,767	0,80	0,167	0,80	0,482	0,80	0,143
0,85	0,817	0,85	0,117	0,85	0,553	0,85	0,092
0,90	0,867	0,90	0,068	0,90	0,626	0,90	0,046
0,95	0,917	0,95	0,023	0,95	0,700	0,95	0,013
1,00	0,967	1,00	0,000	1,00	0,775	1,00	0,000

3.2.8 Calculation of probability for bottom damage *(1/7/2007)*

a) *The probability P_B of breaching a compartment from bottom damage is to be calculated as follows:*

$P_B = P_{BL}\, P_{BT}\, P_{BV}$

where:

$P_{BL} = 1 - P_{Bf} - P_{Ba}$ = *probability the damage will extend into the longitudinal zone bounded by X_a and X_f*

$P_{BT} = 1 - P_{Bp} - P_{Bs}$ = *probability the damage will extend into the transverse zone bounded by Y_p and Y_s*

$P_{BV} = 1 - P_{Bz}$ = *probability the damage will extend vertically above the boundary defined by z*

b) P_{Ba}, P_{Bf}, P_{Bp}, P_{Bs}, *and* P_{Bz} *are to be determined by linear interpolation from the table of probabilities for bottom damage provided in Tab 3, where:*

- P_{Ba} : *the probability the damage will lie entirely aft of location X_a/L;*
- P_{Bf} : *the probability the damage will lie entirely forward of location X_f/L;*
- P_{Bp} : *the probability the damage will lie entirely to port of the tank;*
- P_{Bs} : *the probability the damage will lie entirely to starboard of the tank;*
- P_{Bz} : *the probability the damage will lie entirely below the tank.*

Compartment boundaries X_a, X_f, Y_p, Y_s, and z are to be developed as follows:

X_a and X_f are as defined in [3.2.7];

- Y_p : *the transverse distance from the port-most point on the compartment located at or below the waterline d_B, to a vertical plane located B_B /2 to starboard of the ship's centreline, in metres;*
- Y_s : *the transverse distance from the starboard-most point on the compartment located at or below the waterline d_B, to a vertical plane located B_B /2 to starboard of the ship's centreline, in metres;*
- z : *the minimum value of z over the length of the compartment, where, at any given longitudinal location, z is the vertical distance from the lower point of the bottom shell at that longitudinal location to the lower point of the compartment at that longitudinal location, in metres.*

c) P_{Bz} *is to be calculated as follows:*

$P_{Bz} = (14{,}5 - 67\, z/D_S)\,(z/D_S)$ for $z/D_S \le 0{,}1$

$P_{Bz} = 0{,}78 + 1{,}1\,(z/D_S - 0{,}1)$ for $z/D_S > 0{,}1$

P_{Bz} *is not to be taken greater than 1.*

Table 3 : Probabilities for bottom damage*(1/7/2007)*

X_a/L	P_{Ba}	X_f/L	P_{Bf}	Y_p/B_B	P_{Bp}	Y_s/B_B	P_{Bs}
0,00	0,000	0,00	0,969	0,00	0,844	0,00	0,000
0,05	0,002	0,05	0,953	0,05	0,794	0,05	0,009
0,10	0,008	0,10	0,936	0,10	0,744	0,10	0,032
0,15	0,017	0,15	0,916	0,15	0,694	0,15	0,063
0,20	0,029	0,20	0,894	0,20	0,644	0,20	0,097
0,25	0,042	0,25	0,870	0,25	0,594	0,25	0,133
0,30	0,058	0,30	0,842	0,30	0,544	0,30	0,171
0,35	0,076	0,35	0,810	0,35	0,494	0,35	0,211
0,40	0,096	0,40	0,775	0,40	0,444	0,40	0,253
0,45	0,119	0,45	0,734	0,45	0,394	0,45	0,297
0,50	0,143	0,50	0,687	0,50	0,344	0,50	0,344
0,55	0,171	0,55	0,630	0,55	0,297	0,55	0,394
0,60	0,203	0,60	0,563	0,60	0,253	0,60	0,444
0,65	0,242	0,65	0,489	0,65	0,211	0,65	0,494
0,70	0,289	0,70	0,413	0,70	0,171	0,70	0,544
0,75	0,344	0,75	0,333	0,75	0,133	0,75	0,594
0,80	0,409	0,80	0,252	0,80	0,097	0,80	0,644
0,85	0,482	0,85	0,170	0,85	0,063	0,85	0,694
0,90	0,565	0,90	0,089	0,90	0,032	0,90	0,744
0,95	0,658	0,95	0,026	0,95	0,009	0,95	0,794
1,00	0,761	1,00	0,000	1,00	0,000	1,00	0,844

3.2.9 Alternative calculation procedures *(1/7/2007)*

This requirement uses a simplified probabilistic approach where a summation is carried out over the contributions to the mean outflow from each cargo tank. For certain designs such as those characterised by the occurrence of steps/recesses in bulkheads/decks and for sloping bulkheads and/or a pronounced hull curvature, more rigorous calculations may be appropriate. In such cases one of the following calculation procedures may be applied:

- *The probabilities referred to in [3.2.7] and [3.2.8] may be calculated with more precision through application of hypothetical sub-compartments (see Note 1).*
- *The probabilities referred to in [3.2.7] and [3.2.8] may be calculated through direct application of the probability density functions contained in the IMO Resolutions referred to in [4.2.5].*
- *The oil outflow performance may be evaluated in accordance with the method described in the IMO Resolutions referred to in [4.2.5].*

Note 1: Refer to the "Explanatory Notes on matters related to the accidental oil outflow performance" adopted by IMO Resolution MEPC.122(52).

3.2.10 Credit for reducing oil outflow *(1/7/2007)*

Credit for reducing oil outflow through the use of an emergency rapid cargo transfer system or other system arranged to mitigate oil outflow in the event of an accident may be taken into account only after the effectiveness and safety aspects of the system are approved by the Society. Submittal for approval is to be made in accordance with the provisions of the IMO Resolutions referred to in [4.2.5].

3.3 Slop tanks

3.3.1 Combination carriers of 150 gross tonnage and above

The arrangements of the slop tank or combination of slop tanks are to have a capacity necessary to retain the slop generated by tank washings, oil residues and dirty ballast residues. The total capacity of the slop tank or tanks is to be not less than 3 per cent of the oil carrying capacity of the ships, except that the Society may accept:

- *2% for such combination carriers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for ejectors, without the introduction of additional water into the system*
- *2% where segregated ballast tanks are provided in accordance with [5]. This capacity may be further reduced to 1,5% for such combination carriers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for ejectors, without the introduction of additional water into the system.*
- *1% for combination carriers where oil cargo is only carried in tanks with smooth walls. This capacity may be further reduced to 0,8% where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for ejectors, without the introduction of additional water into the system.*

  The term "tanks with smooth walls" includes the main oil cargo tanks of combination carriers which may be constructed with vertical framing of a small depth. Vertically corrugated bulkheads are considered smooth walls.

3.3.2 Combination carriers of 70000 t deadweight and above

Combination carriers of 70000 t deadweight and above are to be provided with at least two slop tanks.

4 Size and arrangement of protective ballast tanks or compartments

4.1 General

4.1.1 This requirement applies to combination carriers of 600 t deadweight and above.

4.2 Size and arrangement of ballast tanks or compartments

4.2.1 General

The entire oil cargo tank length is to be protected by ballast tanks or compartments other than oil cargo and fuel oil tanks as indicated in [4.2.2] to [4.2.5] for combination carriers of 5000 t deadweight and above, or [4.2.6] for combination carriers less than 5000 t deadweight.

4.2.2 Wing tanks or compartments

Wing tanks or compartments are to extend either for the full depth of the ship side or from the top of the double bottom to the uppermost deck, disregarding a rounded gunwale where fitted. They are to be arranged such that the oil cargo tanks are located inboard of the moulded line of the side shell plating, nowhere less than the distance w which, as shown in Fig 3, is measured at any cross-section at right angles to the side shell, as specified below:

- $w = 0,5 + DW / 20000$, *or*
- $w = 2,0$ *m*

whichever is the lesser.

The value of w is to be at least 1,0 m.

4.2.3 Double bottom tanks or compartments

The requirements of [2.2.1] and [2.2.2] apply.

4.2.4 Aggregate capacity of ballast tanks

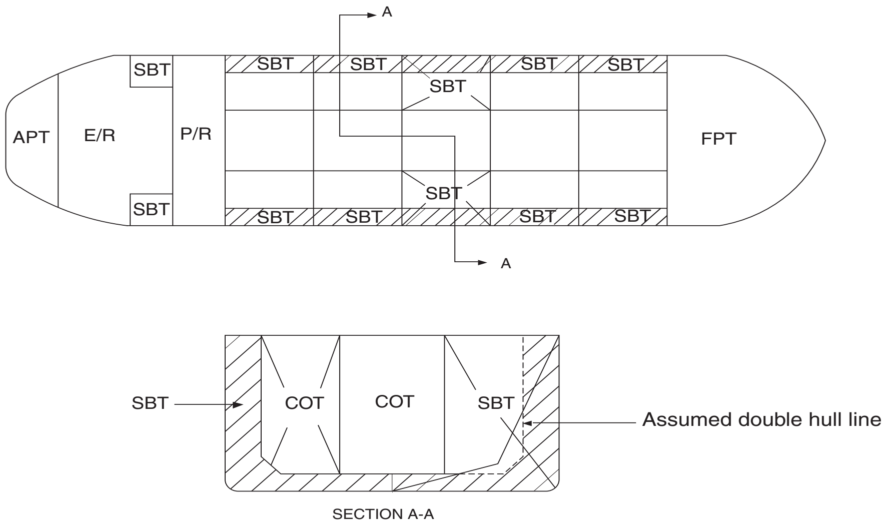
On combination carriers of 20000 t deadweight and above and product carriers of 30000 t deadweight and above, the aggregate capacity of wing tanks, double bottom tanks, fore peak tanks and after peak tanks is to be not less than the capacity of segregated ballast tanks necessary to meet the requirements of [5]. Wing tanks or compartments and double bottom tanks used to meet the requirements of [5] are to be located as uniformly as practicable along the oil cargo tank length. Additional segregated ballast capacity provided for reducing longitudinal hull girder bending stress, trim, etc., may be located anywhere within the ship.

In calculating the aggregate capacity, the following is to be taken into account:

- *the capacity of engine room ballast tanks is to be excluded from the aggregate capacity of ballast tanks*
- *the capacity of ballast tanks located inboard of double hull is to be excluded from the aggregate capacity of ballast tanks (see Fig 5).*

Any ballast carried in localised inboard extensions, indentation or recesses of the double hull, such as bulkhead stools, may be considered as *excess ballast above the minimum requirement for segregated ballast capacity according to [5].*

Figure 5 : Segregated ballast tanks located inboard of double hull



4.2.5 Alternative methods of design and construction *(1/7/2007)*

Other methods of design and construction of combination carriers may also be accepted as alternatives to the requirements prescribed in [4.2.2] to [4.2.4], provided that such methods ensure at least the same level of protection against oil pollution in the event of collision or stranding. Such methods are to be acceptable to the Society.

Note 1: The Society considers the method described in IMO Resolution MEPC.110(49) as being acceptable.

4.2.6 Combination carriers of less than 5000 t deadweight

Combination carriers of less than 5000 t deadweight are to comply with [2.2.3].

5 Size and arrangement of segregated ballast tanks (SBT)

5.1 General

5.1.1 *Every combination carrier of 20000 t deadweight and above and every product carrier of 30000 t deadweight and above is to be provided with segregated ballast tanks and to comply with [5.2].*

5.2 Capacity of SBT

5.2.1 Combination carriers equal to or greater than 150 m in length

The capacity of the segregated ballast tanks is to be so determined that the ship may operate safely on ballast voyages without recourse to the use of oil cargo tanks for water ballast. In all cases, however, the capacity of segregated ballast tanks is to be at least such that, in any ballast condition at any part of the voyage, including the conditions consisting of lightweight plus segregated ballast only, the ship's draughts and trim can meet each of the following requirements:

- *the moulded draught amidships, d_m in metres (without taking into account any ship's deformation), is to be not less than 2,0 + 0,02 L*
- *the draughts at the forward and after perpendicular are to correspond to those determined by the draught amidships d_m as specified above, in association with the trim by the stern of not greater than 0,015L*
- *in any case the draught at the after perpendicular is to be not less than that which is necessary to obtain full immersion of the propeller(s)*
- *in no case is ballast water to be carried in oil cargo tanks, except:*
  - *on those rare voyages when weather conditions are so severe that, in the opinion of the Master, it is necessary to carry additional ballast water in oil cargo tanks for the safety of the ship*
  - *in exceptional cases where the particular character of the operation of a combination carrier renders it necessary to carry ballast water in excess of the quantity required to comply with the requirements above, provided that such operation of the combination carrier falls under the category of exceptional cases.*

5.2.2 Combination carriers less than 150 m in length

The capacity of the segregated ballast tanks is to be considered by the Society on a case-by-case basis.

6 Access arrangement

6.1 Access to double bottom and pipe tunnel

6.1.1 Means of access

Adequate means of access to the double bottom and the pipe tunnel are to be provided.

6.1.2 Manholes in the inner bottom, floors and girders

Manholes may not be cut in the inner bottom in way of oil cargo holds; access to the double bottom is, in general, to be provided by trunks leading to the upper deck.

The location and size of manholes in longitudinal girders and floors are to be determined to facilitate the access to double bottom structures and their ventilation. However, they are to be avoided in the areas where high shear stresses may occur.

6.1.3 Access to pipe tunnels under oil cargo tanks

The pipe tunnel in the double bottom under oil cargo tanks is to comply with the following requirements:

- it may not communicate with the engine room
- provision is to be made for at least two exits to the open deck arranged at a maximum distance from each other. One of these exits fitted with a watertight closure may lead to the cargo pump room.

6.1.4 Doors between pipe tunnel and main pump room

Where there is a permanent access from a pipe tunnel to the main pump room, a watertight door is to be fitted complying with the requirements in Pt B, Ch 2, Sec 1, [6.2.1] for watertight doors open at sea and located below the freeboard deck. In addition the following is to be complied with:

- *in addition to bridge operation, the watertight door is to be capable of being manually closed from outside the main pump room entrance*
- *the watertight door is to be kept closed during normal operations of the ship except when access to the pipe tunnel is required.* A notice is to be affixed to the door to the effect that it may not be left open.

6.2 Access to dry cargo holds

6.2.1 Means of access

As far as practicable, permanent or movable means of access stored on board are to be provided to ensure proper survey and maintenance of dry cargo holds.

6.2.2 Hatches of large cargo holds

When the access to the dry cargo hold is arranged through the cargo hatch, the top of the ladder, as required in [6.2.3], is to be placed as close as possible to the hatch coaming.

Accesses and ladders are to be so arranged that personnel equipped with self-contained breathing apparatus may readily enter and leave the dry cargo hold.

Access hatch coamings having a height greater than 900 mm are also to have steps on the outside in conjunction with dry cargo hold ladders.

6.2.3 Ladders within large cargo holds

Each dry cargo hold is to be provided with at least two ladders as far apart as practicable longitudinally. If possible these ladders are to be arranged diagonally, e.g. one ladder near the forward bulkhead on the port side, the other one near the aft bulkhead on the starboard side, from the ship's centreline.

Ladders are to be so designed and arranged that the risk of damage from the cargo handling gear is minimised.

Vertical ladders may be permitted provided they are arranged above each other in line with other ladders to which they form access and resting positions are provided at not more than 9 metres apart.

Tunnels passing through dry cargo holds are to be equipped with ladders or steps at each end of the hold so that personnel may get across such tunnels.

Where it may be necessary for work to be carried out within a dry cargo hold preparatory to loading, consideration is to be given to suitable arrangements for the safe handling of portable staging or movable platforms.

6.3 Access to compartments in the oil cargo area

6.3.1 General

Access to cofferdams, ballast tanks, dry cargo holds, oil cargo tanks and other compartments in the oil cargo area is to be direct from the open deck and such as to ensure their complete inspection.

6.3.2 Access to the fore peak tank *(1/1/2012)*

The access to the fore peak tank is to be direct from the open deck.

Alternatively, indirect access from the open deck to the fore peak tank through an enclosed space may be accepted provided that:

a) if the enclosed space is separated from the cargo tanks by cofferdams, the access is through a gas-tight bolted manhole located in the enclosed space and a warning sign is provided at the manhole stating that the fore peak tank may only be opened after:
    - it has been proven to be gas-free; or
    - any electrical equipment which is not electrically certified safe in the enclosed space is isolated

b) if the enclosed space has a common boundary with the cargo tanks and is therefore a hazardous area (see Note 1), the enclosed space can be well ventilated.

Note 1: The hazardous area classification is to be defined in accordance with IEC 60092-502: Electrical installations in ships - Tankers - Special features.

6.3.3 Access through horizontal openings

For access through horizontal openings the dimensions are to be sufficient to allow a person wearing a self-contained, air-breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the compartment. The minimum clear opening is to be not less than 600 mm by 600 mm.

6.3.4 Access through vertical openings

For access through vertical openings the minimum clear opening is to be not less than 600 mm by 800 mm at a height of not more than 600 mm from the bottom shell plating unless gratings or other footholds are provided.

6.4 Access to the bow

6.4.1 *(1/7/2008)*

This item [6.4] applies to ships subject to the International Load Line Convention 1966, as amended.

6.4.2 *Combination carriers are to be provided with the means to enable the crew to gain safe access to the bow even in severe weather conditions. Such means are to be accepted by the Society.*

Note 1: The Society considers means in compliance with the Guidelines adopted by the Maritime Safety Committee of IMO with Resolution MSC.62(67) on 5/12/1996 as being acceptable.

SECTION 3 HULL AND STABILITY

Symbols

R_y : Minimum yield stress, in N/mm², of the material, to be taken equal to 235/k N/mm², unless otherwise specified

k : Material factor for steel, defined in Pt B, Ch 4, Sec 1, [2.3]

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

- E = 2,06.10⁵ N/mm², for steels in general
- E = 1,95.10⁵ N/mm², for stainless steels.

1 General

1.1 Loading manual and loading instrument

1.1.1 The specific requirements in Pt B, Ch 11, Sec 2 for ships with either of the service notations **combination carrier/OBO ESP** or **combination carrier/OOC ESP** and equal to or greater than 150 m in length are to be complied with.

2 Stability

2.1 Intact stability

2.1.1 General

The stability of the ship for the loading conditions in Pt B, Ch 3, App 2, [1.2.5] is to be in compliance with the requirements in Pt B, Ch 3, Sec 2. Where the ship is intended also for the carriage of grain, the requirements in Ch 4, Sec 3, [2.2.2] and Ch 4, Sec 3, [2.2.3] are to be complied with.

In addition, for the carriage of liquids, the requirements in [2.1.3] are to be complied with.

2.1.2 Liquid transfer operations

Ships with certain internal subdivision may be subjected to lolling during liquid transfer operations such as loading, unloading or ballasting. In order to prevent the effect of lolling, the design of oil tankers of 5000 t deadweight and above is to be such that the following criteria are complied with*:*

a) *The intact stability criteria reported in b) are to be complied with for* the worst possible condition of loading and ballasting as defined in c)*, consistent with good operational practice, including the intermediate stages of liquid transfer operations. Under all conditions the ballast tanks are to be assumed slack.*

b) *The initial metacentric height GM_o, in m, corrected for free surface measured at 0° heel, is to be not less than 0,15. For the purpose of calculating GM_o, liquid surface corrections are to be based on the appropriate upright free surface inertia moment.*

c) *The vessel is to be loaded with:*
   - *all cargo tanks filled to a level corresponding to the maximum combined total of vertical moment of volume plus free surface inertia moment at 0° heel, for each individual tank*
   - *cargo density corresponding to the available cargo deadweight at the displacement at which transverse KM reaches a minimum value*
   - *full departure consumable*
   - *1% of the total water ballast capacity. The maximum free surface moment is to be assumed in all ballast tanks.*

2.1.3 Alternative requirements for liquid transfer operation

As an alternative to the requirements in [2.1.2], simple supplementary operational procedures are to be followed when the ship is carrying oil cargoes or during liquid transfer operations.

Simple supplementary operational procedures for liquid transfer operations means written procedures made available to the Master which:

- *are approved by the Society,*
- *indicate those cargo and ballast tanks which may, under any specific condition of liquid transfer and possible range of cargo densities, be slack and still allow the stability criteria to be met. The slack tanks may vary during the liquid transfer operations and be of any combination provided they satisfy the criteria.*
- *are to be readily understandable to the officer-in-charge of liquid transfer operations,*
- *provide for planned sequences of cargo/ballast transfer operations,*
- *allow comparisons of attained and required stability using stability performance criteria in graphical or tabular form,*
- *require no extensive mathematical calculations by the officer-in-charge,*
- *provide for corrective actions to be taken by the officer-in-charge in the event of departure from the recommended values and in case of emergency situations, and,*
- *are prominently displayed in the approved trim and stability booklet and at the cargo/ballast transfer control station and in any computer software by which stability calculations are performed.*

3 Structure design principles of ships with the service notation combination carrier/OBO ESP

3.1 Double bottom structure

3.1.1 Longitudinally framed double bottom

In ships greater than 120 m in length, the double bottom and the sloped bulkheads of hopper tanks are to be longitudinally framed.

The girder spacing is to be not greater than 4 times the spacing of bottom or inner bottom ordinary stiffeners and the floor spacing is to be not greater than 3 frame spaces.

Greater spacing may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo holds.

3.1.2 Transversely framed double bottom

The double bottom and the sloped bulkheads of hopper tanks may be transversely framed in ships less than or equal to 120 m in length, when this is deemed acceptable by the Society on a case-by-case basis. In this case, however, the floor spacing is to be not greater than 2 frame spaces.

3.1.3 Floors in way of transverse bulkheads

The thickness and material properties of the supporting floors and pipe tunnel beams are to be not less than those required for the bulkhead plating or, when a stool is fitted, of the stool side plating.

3.2 Double side structure

3.2.1 General

The side within the hopper and topside tanks is, in general, to be longitudinally framed. It may be transversely framed when this is accepted for the double bottom and the deck according to [3.1.2] and [3.3.1], respectively.

3.2.2 Side primary supporting members

The spacing of transverse side primary supporting members is to be not greater than 3 frame spaces.

Greater spacing may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo holds.

In any case, transverse side primary supporting members are to be fitted in line with transverse primary supporting members in hopper and topside tanks.

3.3 Deck structure

3.3.1 Deck outside the line of hatches and topside tank sloping plates

In ships greater than 120 m in length, the deck outside the line of hatches and the topside tank sloping plates are to be longitudinally framed.

The spacing of transverse primary supporting members in topside tanks is to be not greater than 6 frame spaces.

Greater spacing may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo holds.

3.3.2 Deck between hatches

The cross decks between hatches are generally to be transversely framed.

3.3.3 Connection of hatch end beams with deck structures

The connection of hatch end beams with deck structures is to be properly ensured by fitting inside the topside tanks additional web frames or brackets.

3.3.4 Topside tank structure

Topside tank structures are to extend as far as possible within the machinery space and are to be adequately tapered.

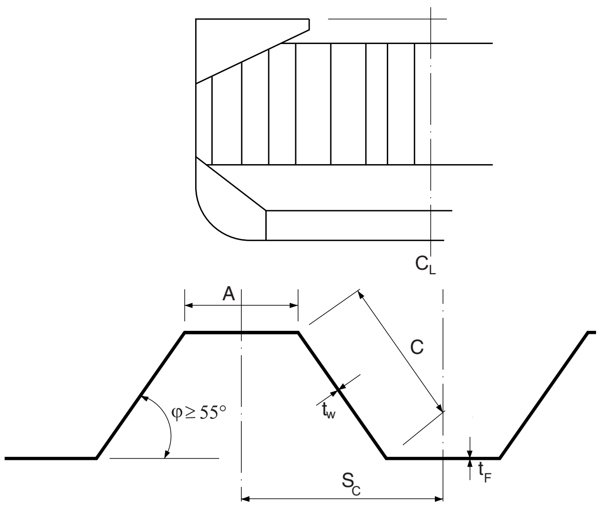
3.4 Transverse vertically corrugated watertight bulkhead

3.4.1 General *(1/7/2004)*

In ships equal to or greater than 190 m in length, transverse vertically corrugated watertight bulkheads are to be fitted with a lower stool and, in general, with an upper stool below the deck. In smaller ships, corrugations may extend from the inner bottom to the deck; if the stool is fitted, it is to comply with the requirements in [3.4.1] to [3.4.5].

The corrugation angle φ shown in Fig 1 is to be not less than 55°.

Figure 1 : Corrugation geometry

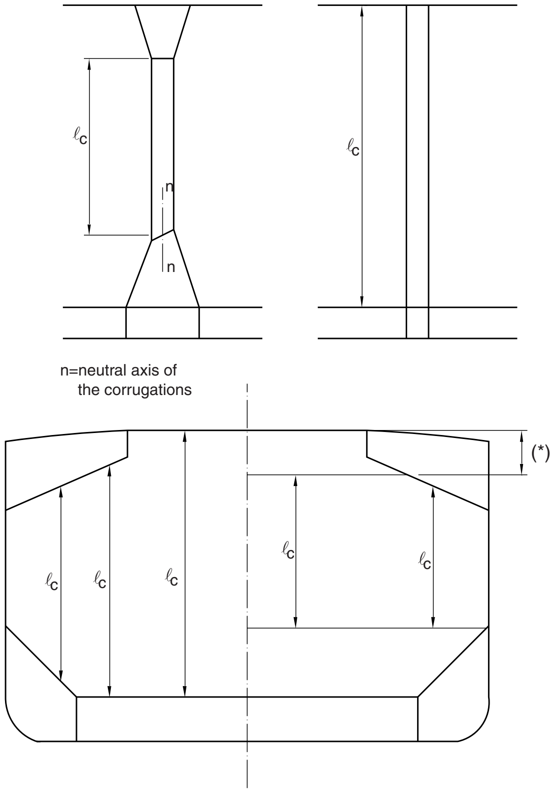


3.4.2 Span of corrugations

The span ℓ_C of the corrugations (to be used for carrying out the strength checks according to Pt B, Ch 7, Sec 2 or Pt B, Ch 8, Sec 4, as the case may be) is to be taken as the distance shown in Fig 2. For the definition of ℓ_C, the internal end of the upper stool may not be taken at a distance from the deck at centreline greater than:

- 3 times the depth of corrugations, in general
- twice the depth of corrugations, for rectangular upper stools.

Figure 2 : Span of the corrugations



(*) See [3.4.2].

3.4.3 Lower stool *(1/7/2001)*

The lower stool, when fitted, is to have a height in general not less than 3 times the depth of the corrugations.

The thickness and material of the stool top plate is to be not less than those required for the bulkhead plating above. The thickness and material properties of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top are to be not less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at the lower end of corrugation.

The ends of stool side ordinary stiffeners are to be attached to brackets at the upper and lower ends of the stool.

The distance from the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with Fig 3 .

The stool bottom is to be installed in line with double bottom floors and is to have a width not less than 2,5 times the mean depth of the corrugation.

The stool is to be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate are to be avoided.

Where corrugations are cut at the lower stool, the weld connections of corrugations and stool side plating to the stool top plate are to be in accordance with [13.1]. The weld connections of stool side plating and supporting floors to the inner bottom plating are to be in accordance with [13.1].

3.4.4 Upper stool

The upper stool, when fitted, is to have a height in general between 2 and 3 times the depth of corrugations. Rectangular stools are to have a height in general equal to twice the depth of corrugations, measured from the deck level and at the hatch side girder.

The upper stool is to be properly supported by deck girders or deep brackets between the adjacent hatch end beams.

The width of the upper stool bottom plate is generally to be the same as that of the lower stool top plate. The stool top of non-rectangular stools is to have a width not less then twice the depth of corrugations.

The thickness and material of the stool bottom plate are to be the same as those of the bulkhead plating below. The thickness of the lower portion of stool side plating is to be not less than 80% of that required for the upper part of the bulkhead plating where the same material is used.

The ends of stool side ordinary stiffeners are to be attached to brackets at the upper and lower end of the stool.

The stool is to be fitted with diaphragms in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate are to be avoided.

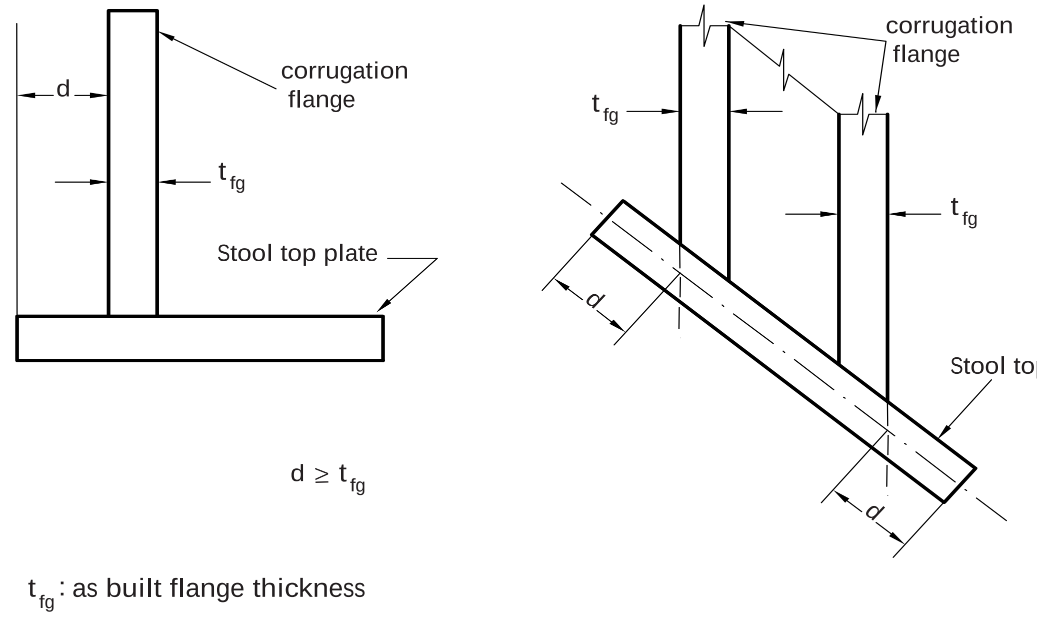
3.4.5 Alignment

At deck, if no upper stool is fitted, two transverse reinforced beams are to be fitted in line with the corrugation flanges.

At bottom, if no lower stool is fitted, the corrugation flanges are to be in line with the supporting floors. The weld connections of corrugations and floors to the inner bottom plating are to be in accordance with [12.1]. The thickness and material properties of the supporting floors are to be not less than those of the corrugation flanges. Moreover, the cut-outs for connections of the inner bottom longitudinals to double bottom floors are to be closed by collar plates. The supporting floors are to be connected to each other by suitably designed shear plates.

Stool side plating is to align with the corrugation flanges; lower stool side vertical stiffeners and their brackets in the stool are to align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Lower stool side plating may not be knuckled anywhere between the inner bottom plating and the stool top plate.

Figure 3 : Permitted distance, d, from the edge of the stool top plate to the surface of the corrugation flange



3.4.6 Effective width of the compression flange

The effective width of the corrugation flange to be considered for the strength check of the bulkhead is to be obtained, in m, from the following formula:

$$b_{EF} = C_E A$$

where:

C_E : Coefficient to be taken equal to:

$$C_E = \frac{2,25}{\beta} - \frac{1,25}{\beta^2} \quad \text{for } \beta > 1,25$$

$$C_E = 1,0 \quad \text{for } \beta \leq 1,25$$

β : Coefficient to be taken equal to:

$$\beta = 10^3 \frac{A}{t_f}\sqrt{\frac{R_{eH}}{E}}$$

A : Width, in m, of the corrugation flange (see Fig 1)

t_f : Net flange thickness, in mm

R_{eH} : Minimum yield stress, in N/mm², of the flange material, defined in Pt B, Ch 4, Sec 1, [2].

3.4.7 Effective shedder plates

Effective shedder plates are those which:

- are not knuckled
- are welded to the corrugations and the lower stool top plate according to [13.1]
- are fitted with a minimum slope of 45°, their lower edge being in line with the lower stool side plating
- have thickness not less than 75% of that required for the corrugation flanges
- have material properties not less than those required for the flanges.

3.4.8 Effective gusset plates

Effective gusset plates are those which:

- are in combination with shedder plates having thickness, material properties and welded connections according to [3.4.7]
- have a height not less than half of the flange width
- are fitted in line with the lower stool side plating
- are welded to the lower stool plate, corrugations and shedder plates according to [13.1]
- have thickness and material properties not less than those required for the flanges.

3.4.9 Section modulus at the lower end of corrugations

a) The section modulus at the lower end of corrugations (sections 1 in Fig 4 to Fig 8) is to be calculated with the compression flange having an effective flange width b_{ef}, not larger than that indicated in [3.4.6].

b) Webs not supported by local brackets.

Except in case e), if the corrugation webs are not supported by local brackets below the stool top plate (or below the inner bottom) in the lower part, the section modulus of the corrugations is to be calculated considering the corrugation webs 30% effective.

c) Effective shedder plates.

Provided that effective shedder plates, as defined in [3.4.7], are fitted (see Fig 4 and Fig 5), when calculating the section modulus of corrugations at the lower end (sections 1 in Fig 4 and Fig 5), the area of flange plates may be increased by the value obtained, in cm², from the following formula:

$$I_{SH} = 2{,}5A\sqrt{t_F t_{SH}}$$

without being taken greater than $2{,}5At_F$,

where:

A : Width, in m, of the corrugation flange (see Fig 1)

t_{SH} : Net shedder plate thickness, in mm

t_F : Net flange thickness, in mm.

d) Effective gusset plates.

Provided that effective gusset plates, as defined in [3.4.8], are fitted (see Fig 6 to Fig 8), when calculating the section modulus of corrugations at the lower end (cross-sections 1 in Fig 6 to Fig 8), the area of flange plates may be increased by the value obtained, in cm^2, from the following formula:

$$I_G = 7h_G t_F$$

where:

h_G : Height, in m, of gusset plate (see Fig 6 to Fig 8), to be taken not greater than $(10/7)S_{GU}$,

S_{GU} : Width, in m, of the gusset plates

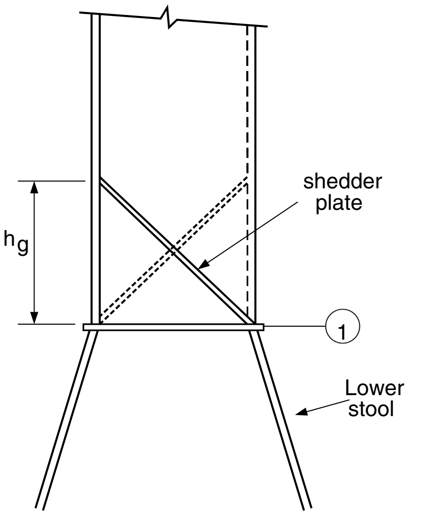
t_F : Net flange thickness, in mm, based on the as-built condition.

e) Sloping stool top plate

If the corrugation webs are welded to a sloping stool top plate which has an angle not less than 45° with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. For angles less than 45°, the effectiveness of the web may be obtained by linear interpolation between 30% for 0° and 100% for 45°.

Where effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in d) above. No credit may be given to shedder plates only.

Figure 4 : Symmetrical shedder plates



3.4.10 Section modulus at sections other than the lower end of corrugations

The section modulus is to be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{EF}, not larger than that obtained in [3.4.6].

3.4.11 Shear area

The shear area is to be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by ($\sin \varphi$), φ being the angle between the web and the flange (see Fig 1).

Figure 5 : Asymmetrical shedder plates

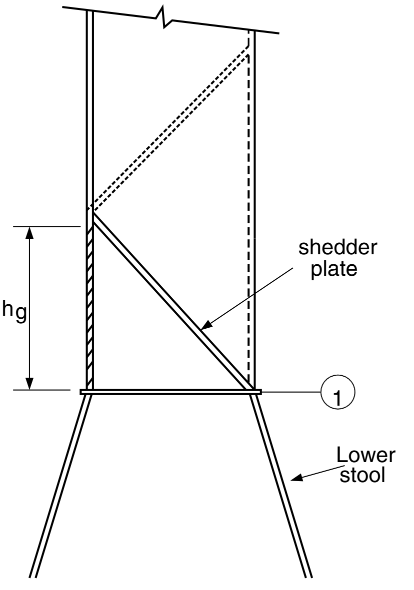


Figure 6 : Symmetrical gusset/shedder plates

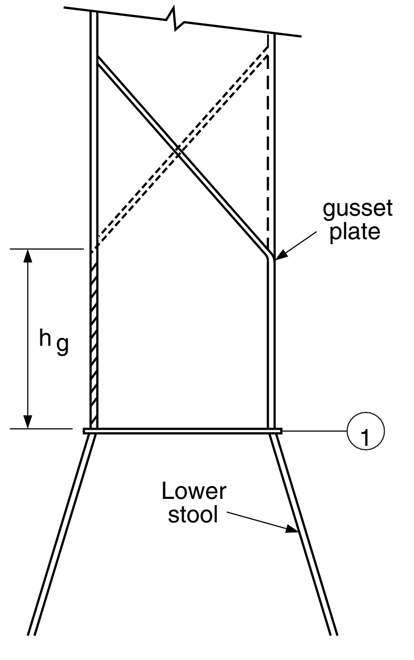


Figure 7 : Asymmetrical gusset/shedder plates

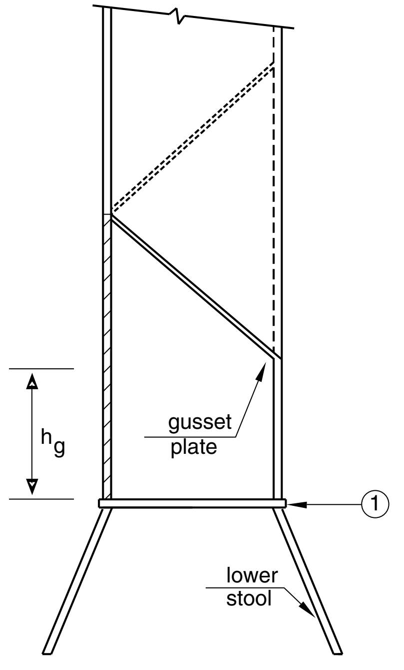
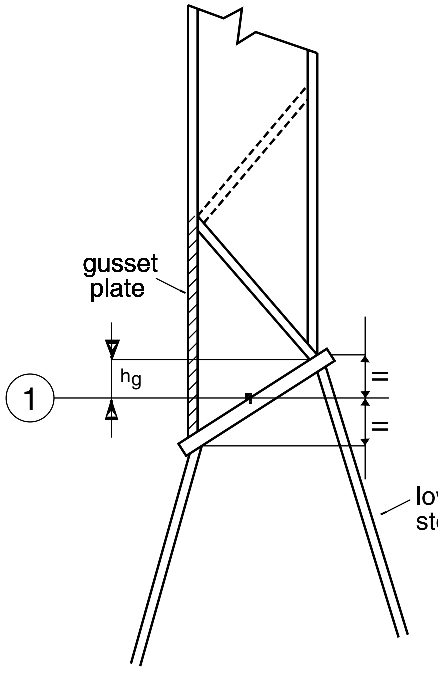


Figure 8 : Asymmetrical gusset/shedder plates
Sloping stool top plate



4 Structure design principles of ships with the service notation combination carrier/OOC ESP

4.1 Double bottom structure

4.1.1 The double bottom is to be longitudinally framed.

The girder spacing is to be not greater than 4 times the spacing of bottom or inner bottom ordinary stiffeners and the floor spacing is to be not greater than 3 frame spaces.

Solid floors are to be fitted in line with the transverse primary supporting members in wing tanks and intermediate floors are to be added at mid-span between primary supporting members.

4.1.2 Other arrangements may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo holds.

4.1.3 Scarfing of the double bottom structure into the wing tanks is to be properly ensured. The inner bottom plating is generally to be prolonged within the wing tanks by adequately sized horizontal brackets in way of floors.

4.2 Side structure

4.2.1 In ships greater than 120 m in length, the side shell is to be longitudinally framed.

In general, the spacing of vertical primary supporting members is to be not greater than 6 times the frame spacing.

4.2.2 Other arrangements may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo hold.

4.3 Deck structure

4.3.1 The deck outside the line of hatches is to be longitudinally framed.

4.3.2 The cross decks between hatches are generally to be transversely framed.

4.3.3 The connection of hatch end beams with deck structures is to be properly ensured by fitting inside the wing tanks additional web frames or brackets.

4.4 Longitudinal bulkhead structure

4.4.1 Longitudinals bulkheads are to be plane, but they may be knuckled in the upper part and in the lower part to form a hopper. In these cases, the design of the knuckles and the adjacent structures is to be considered by the Society on a case-by-case basis.

4.4.2 In ships greater than 120 m in length, longitudinal bulkheads are to be longitudinally framed.

4.4.3 Other arrangements may be accepted by the Society, on a case-by-case basis, depending on the results of the analysis carried out according to Pt B, Ch 7, App 1 for the primary supporting members in the cargo hold.

4.5 Transverse bulkhead structure

4.5.1 Where the structural arrangement of transverse bulkheads in wing tanks is different from that in centre holds, arrangements are to be made to ensure continuity of the transverse strength through the longitudinal bulkheads.

4.6 Transverse vertically corrugated watertight bulkheads

4.6.1 The requirements in [3.4] apply, with the exception that lower and upper stools are generally required, irrespective of the ship's length (see [3.4.1]).

5 Design loads

5.1 Hull girder loads

5.1.1 Still water loads *(1/7/2002)*

In addition to the requirements in Pt B, Ch 5, Sec 2, [2.1.2], still water loads are to be calculated for the following loading conditions, subdivided into departure and arrival conditions as appropriate:

- alternate light and heavy cargo (dry or oil) loading conditions at maximum draught, where applicable
- homogeneous light and heavy cargo (dry or oil) loading conditions at maximum draught
- ballast conditions. For ships having ballast holds adjacent to topside wing, hopper and double bottom tanks, it may be acceptable in terms of strength that the ballast holds are filled when the topside wing, hopper and double bottom tanks are empty.
- short voyage conditions where the ship is to be loaded to maximum draught but with a limited amount of bunkers
- multiple port loading/unloading conditions
- deck cargo conditions, where applicable
- typical loading sequences where the ship is loaded from commencement of cargo loading to reaching full deadweight capacity, for homogeneous conditions, relevant part load conditions and alternate conditions where applicable. Typical unloading sequences for these conditions are also to be included. The typical loading/unloading sequences are also to be developed so as not to exceed applicable strength limitations. The typical loading sequences are also to be developed paying due attention to the loading rate and deballasting capability
- typical sequences for change of ballast at sea, where applicable.

5.2 Local loads

5.2.1 Bottom impact pressure

For combination carriers of 20000 t deadweight and above, the draught T_F, to be considered in the calculation of the bottom impact pressure according to Pt B, Ch 9, Sec 1, [3.2], is that calculated by using the segregated ballast tanks only.

5.2.2 Oil cargo mass density

In the absence of more precise values, an oil cargo mass density of 0,9 t/m^3 is to be considered for calculating the internal pressures and forces in cargo tanks according to Pt B, Ch 5, Sec 6.

6 Hull scantlings

6.1 Plating

6.1.1 Minimum net thicknesses *(1/7/2002)*

The net thickness of the plating of the inner bottom in holds intended to carry ore, of the strength deck and of bulkheads within or bounding the longitudinal extension of the cargo area is to be not less than the values given in Tab 1.

Table 1 : Minimum net thickness of the plating of the inner bottom in holds intended to carry ore, of the strength deck and of bulkheads

Plating	Minimum net thickness, in mm		
Inner bottom in holds intended to carry ore	Longitudinal framing	$2,15 (L^{1/3} k^{1/6}) + 4,5 s$	
	Transverse framing	$2,35 (L^{1/3} k^{1/6}) + 4,5 s$	
Strength deck	$(5,5 + 0,02 L) k^{1/2}$ $(8 + 0,0085 L) k^{1/2}$		for $L < 200$ m for $L \geq 200$ m
Tank bulkhead	$L^{1/3} k^{1/6} + 4,5 s$ $1,5 k^{1/2} + 8,2 + s$		for $L < 275$ m for $L \geq 275$ m
Watertight bulkhead	$0,85 L^{1/3} k^{1/6} + 4,5 s$ $1,5 k^{1/2} + 7,5 + s$		for $L < 275$ m for $L \geq 275$ m
Wash bulkhead	$0,8 + 0,013 L k^{1/2} + 4,5 s$ $3,0 k^{1/2} + 4,5 + s$		for $L < 275$ m for $L \geq 275$ m
Note 1: s : Length, in m, of the shorter side of the plate panel.			

6.2 Ordinary stiffeners

6.2.1 Minimum net thicknesses

The net thickness of the web of ordinary stiffeners is to be not less than the value obtained, in mm, from the following formulae:

$t_{MIN} = 0,75 L^{1/3} k^{1/6} + 4,5 s$ for $L < 275$ m

$t_{MIN} = 1,5 k^{1/2} + 7,0 + s$ for $L \geq 275$ m

where s is the spacing, in m, of ordinary stiffeners.

6.3 Primary supporting members

6.3.1 Minimum net thicknesses

The net thickness of plating which forms the webs of primary supporting members is to be not less than the value obtained, in mm, from the following formula:

$t_{MIN} = 1,45 L^{1/3} k^{1/6}$

6.3.2 Strength check of floors of cargo tank structure with hopper tank analysed through a three dimensional beam model

Where the cargo tank structure with hopper tank is analysed through a three dimensional beam model, to be carried out according to Pt B, Ch 7, App 1, the net shear sectional area of floors within 0,1 ℓ from the floor ends (see Fig 9 for the definition of ℓ) is to be not less than the value obtained, in cm^2, from the following formula:

$$A_{Sh} = 2\frac{Q}{\gamma_R \gamma_m R_y}$$

where:

Q : Shear force, in kN, in the floors at the ends of ℓ, obtained from the structural analysis

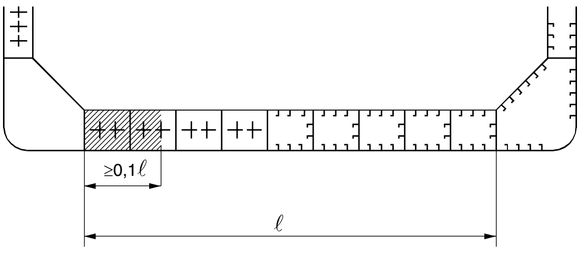
γ_R : Resistance partial safety factor:

$\gamma_R = 1,2$

γ_m : Material partial safety factor:

$\gamma_m = 1,02$

Figure 9 : End area of floors



6.3.3 Strength checks of cross-ties analysed through a three dimensional beam model

a) Cross-ties analysed through three dimensional beam model analyses according to Pt B, Ch 7, Sec 3 are to be considered, in the most general case, as being subjected to axial forces and bending moments around the neutral axis perpendicular to the cross-tie web. This axis is identified as the y axis, while the x axis is that in the web plane (see Figures in Tab 2).

The axial force may be either tensile or compression. Depending on this, two types of checks are to be carried out, according to b) or c), respectively.

b) Strength check of cross-ties subjected to axial tensile forces and bending moments.

The net scantlings of cross-ties are to comply with the following formula:

$$10\frac{F_T}{A_{ct}} + 10^3\frac{M}{w_{yy}} \le \frac{R_y}{\gamma_R \gamma_m}$$

where:

F_T : Axial tensile force, in kN, in the cross-ties, obtained from the structural analysis

A_{ct} : Net sectional area, in cm^2, of the cross-tie

M : Max ($|M_1|$, $|M_2|$)

M_1, M_2 : Algebraic bending moments, in kN.m, around the y axis at the ends of the cross-tie, obtained from the structural analysis

w_{yy} : Net section modulus, in cm^3, of the cross-tie about the y axis

γ_R : Resistance partial safety factor:

$\gamma_R = 1,02$

γ_m : Material partial safety factor:

$\gamma_m = 1,02$

c) Strength check of cross-ties subjected to axial compressive forces and bending moments.

The net scantlings of cross-ties are to comply with the following formulae:

$$10F_C\left(\frac{1}{A_{ct}} + \frac{\Phi e}{w_{xx}}\right) \le \frac{R_y}{\gamma_R \gamma_m}$$

$$10\frac{F_C}{A_{ct}} + 10^3\frac{M_{max}}{w_{yy}} \le \frac{R_y}{\gamma_R \gamma_m}$$

where:

F_C : Axial compressive force, in kN, in the cross-ties, obtained from the structural analysis

A_{ct} : Net cross-sectional area, in cm^2, of the cross-tie

$$\Phi = \frac{1}{1 - \frac{F_C}{F_{EX}}}$$

F_{EX} : Euler load, in kN, for buckling around the x axis:

$$F_{EX} = \frac{\pi^2 E I_{xx}}{10^5 \ell^2}$$

I_{xx} : Net moment of inertia, in cm^4, of the cross-tie about the x axis

ℓ : Span, in m, of the cross-tie

e : Distance, in cm, from the centre of gravity to the web of the cross-tie, specified in Tab 2 for various types of profiles

w_{ww} : Net section modulus, in cm^3, of the cross-tie about the x axis

M_{max} : Max ($|M_0|$, $|M_1|$, $|M_2|$)

$$M_0 = \frac{\sqrt{1+t^2}(M_1 + M_2)}{2\cos(u)}$$

$$t = \frac{1}{\tan(u)}\left(\frac{M_2 - M_1}{M_2 + M_1}\right)$$

$$u = \frac{\pi}{2}\sqrt{\frac{F_C}{F_{EY}}}$$

F_{EY} : Euler load, in kN, for buckling around the y axis:

$$F_{EY} = \frac{\pi^2 E I_{yy}}{10^5 \ell^2}$$

I_{yy} : Net moment of inertia, in cm^4, of the cross-tie about the y axis

M_1,M_2 : Algebraic bending moments, in kN.m, around the y axis at the ends of the cross-tie, obtained from the structural analysis

w_{yy} : Net section modulus, in cm^3, of the cross-tie about the y axis

γ_R : Resistance partial safety factor:

$\gamma_R = 1,02$

γ_m : Material partial safety factor:

$\gamma_m = 1,02$

6.3.4 Strength checks of cross-ties analysed through a three dimensional finite element model

a) In addition to the requirements in Pt B, Ch 7, Sec 3, [4] and Pt B, Ch 7, Sec 3, [6], the net scantlings of cross-ties subjected to compression axial stresses are to comply with the following formula:

$$|\sigma| \le \frac{\sigma_C}{\gamma_R \gamma_m}$$

where:

- σ : Compressive stress, in N/mm², obtained from a three dimensional finite element analysis, based on fine mesh modelling, according to Pt B, Ch 7, Sec 3 and Pt B, Ch 7, App 1
- σ_c : Critical stress, in N/mm², defined in b) below
- γ_R : Resistance partial safety factor:

  $\gamma_R = 1{,}02$
- γ_m : Material partial safety factor:

  $\gamma_m = 1{,}02$

b) The critical buckling stress of cross-ties is to be obtained, in N/mm², from the following formulae:

$$\sigma_c = \sigma_E \quad \text{for} \quad \sigma_E \le \frac{R_y}{2}$$

$$\sigma_c = R_y\left(1 - \frac{R_y}{4\sigma_E}\right) \quad \text{for} \quad \sigma_E > \frac{R_y}{2}$$

where:

$\sigma_E = \text{Min}(\sigma_{E1}, \sigma_{E2})$,

- σ_{E1} : Euler flexural buckling stress, to be obtained, in N/mm², from the following formula:

$$\sigma_{E1} = \frac{\pi^2 E I}{10^4 A_{ct} \ell^2}$$

- I : Min (I_{xx}, I_{yy}),
- I_{xx} : Net moment of inertia, in cm⁴, of the cross-tie about the x axis defined in [6.3.3] a)
- I_{yy} : Net moment of inertia, in cm⁴, of the cross-tie about the y axis defined in [6.3.3] a)
- A_{ct} : Net cross-sectional area, in cm², of the cross-tie,
- ℓ : Span, in m, of the cross-tie
- σ_{E2} : Euler torsional buckling stress, to be obtained, in N/mm², from the following formula:

$$\sigma_{E2} = \frac{\pi^2 E I_w}{10^4 I_o \ell^2} + 0{,}41 E \frac{J}{I_o}$$

- I_w : Net sectorial moment of inertia, in cm⁶, of the cross-tie, specified in Tab 2 for various types of profiles
- I_o : Net polar moment of inertia, in cm⁴, of the cross-tie,

$$I_o = I_{xx} + I_{yy} + A_{ct}(y_o + e)^2$$

- y_o : Distance, in cm, from the centre of torsion to the web of the cross-tie, specified in Tab 2 for various types of profiles
- e : Distance, in cm, from the centre of gravity to the web of the cross-tie, specified in Tab 2 for various types of profiles
- J : St. Venant's net moment of inertia, in cm⁴, of the cross-tie, specified in Tab 2 for various types of profiles.

6.4 Strength check with respect to stresses due to the temperature gradient

6.4.1 *(1/7/2018)*

Direct calculations of stresses induced in the hull structures by the temperature gradient are to be performed for ships intended to carry cargoes at temperatures exceeding 90°C. In these calculations, the water temperature is to be assumed equal to 0°C.

The calculations are to be submitted to the Society for review.

6.4.2 The stresses induced in the hull structures by the temperature gradient are to comply with the checking criteria in Pt B, Ch 7, Sec 3, [4.3].

7 Forecastle

7.1 General

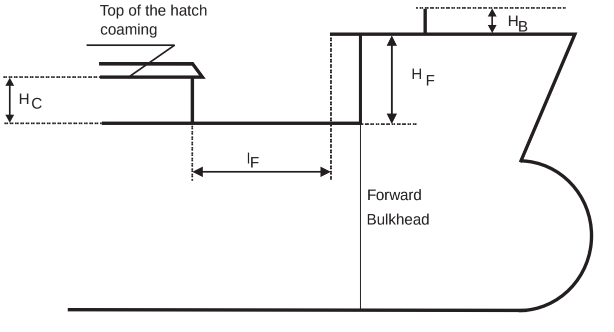
7.1.1 *(1/1/2004)*

Ships with service notation **combination carrier ESP** are to be fitted with an enclosed forecastle on the freeboard deck.

The required dimensions of the forecastle are defined in [7.2].

The structural arrangements and scantlings of the forecastle are to comply with the requirements in Pt B, Ch 10, Sec 2.

Figure 10 : Forecastle arrangement *(1/1/2004)*



7.2 Dimensions

7.2.1 *(1/7/2006)*

The forecastle is to be located on the freeboard deck with its aft bulkhead fitted in way or aft of the forward bulkhead of the foremost hold, as shown in Fig 10.

However, if this requirement hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided that the forecastle length aft FE is not less than $0{,}07L_{LL}$, where:

- FE : Fore end of the length L, as defined in Pt B, Ch 1, Sec 2, [3.3.1]
- L_{LL} : Freeboard length, as defined in Pt B, Ch 1, Sec 2, [3.2]

The forecastle height H_F above the main deck is to be not less than the greater of:

- the standard height of a superstructure, as specified in Pt B, Ch 1, Sec 2, Tab 2, or
- H_C + 0,5 m, where H_C is the height of the forward transverse hatch coaming of cargo hold No.1.

All points of the aft edge of the forecastle deck are to be located at a distance l_F, in compliance with the following formula, from the hatch coaming plate in order to apply the reduced loading to the No.1 forward transverse hatch coaming and No.1 hatch cover in applying Pt B, Ch 9, Sec 7, [3.3.2] and Pt B, Ch 9, Sec 7, [7.2.3], respectively:

$$l_F \leq 5\sqrt{H_F - H_C}$$

A breakwater may not be fitted on the forecastle deck with the purpose of protecting the hatch coaming or hatch covers. If fitted for other purposes, it is to be located such that its upper edge at centreline is not less than H_B / tan20° forward of the aft edge of the forecastle deck, where H_B is the height of the breakwater above the forecastle (see Fig 10).

8 Machinery space

8.1 Extension of hull structures within the machinery space

8.1.1 Longitudinal bulkheads or inner side, as applicable, carried through cofferdams are to continue within the machinery space and are to be used preferably as longitudinal bulkheads for liquid cargo tanks. In any case, such extension is to be compatible with the shape of the structures of the double bottom, deck and platforms of the machinery space.

Where topside tanks are fitted, their structures are to extend as far as possible within the machinery space and to be adequately tapered.

9 Hatch covers, hatch coamings and closing devices

9.1 Application

9.1.1 *(1/7/2024)*

Refer to the requirements for Type 2 ships in Pt B, Ch 9, Sec 7.

10 Opening arrangement

10.1 Tanks covers

10.1.1 Covers fitted on all cargo tank openings are to be of sturdy construction, and to ensure tightness for hydrocarbon and water.

Aluminium is not permitted for the construction of tank covers. The use of reinforced fibreglass covers is to be specially examined by the Society.

11 Hull outfitting

11.1 Equipment

11.1.1 Emergency towing arrangement

The specific requirements in Pt B, Ch 10, Sec 4, [4] for ships with either of the service notations **combination carrier/OBO ESP** or **combination carrier/OOC ESP** and of 20000 t deadweight and above are to be complied with.

12 Protection of hull metallic structures

12.1 Protection of sea water ballast tanks

12.1.1 *All dedicated seawater ballast tanks are to have an efficient corrosion prevention system, such as hard protective coatings or equivalent.*

The coatings are preferably to be of a light colour, i.e. a colour easily distinguishable from rust which facilitates inspection.

Where appropriate, sacrificial anodes may also be used.

12.2 Protection by aluminium coatings

12.2.1 *(1/1/2014)*

The use of aluminium coatings containing more than 10 percent aluminium by weight in the dry film is prohibited in cargo tanks, the cargo tank deck area, pump rooms, cofferdams or any other area where cargo vapour may accumulate.

13 Construction and testing

13.1 Welding and weld connections

13.1.1 The welding factors for some hull structural connections are specified in Tab 3. These welding factors are to be used, in lieu of the corresponding factors specified in Pt B, Ch 12, Sec 1, Tab 2, to calculate the throat thickness of fillet weld T connections according to Pt B, Ch 12, Sec 1, [2.3]. For the connections in Tab 3, continuous fillet welding is to be adopted.

13.2 Special structural details

13.2.1 The specific requirements in Pt B, Ch 12, Sec 2, [2.6] for ships with either of the service notations **combination carrier/OBO ESP** or combination carrier/OOC ESP are to be complied with.

Table 2 : Calculation of cross-tie geometric properties

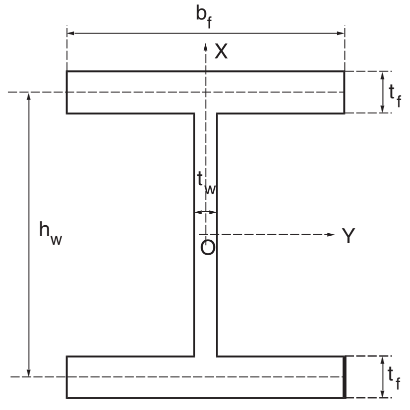
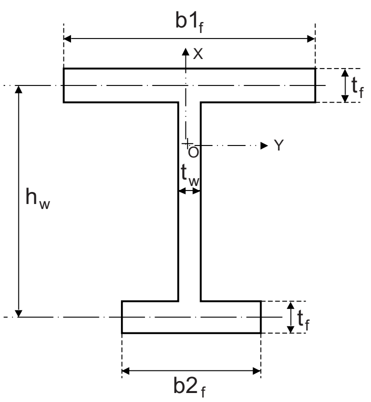
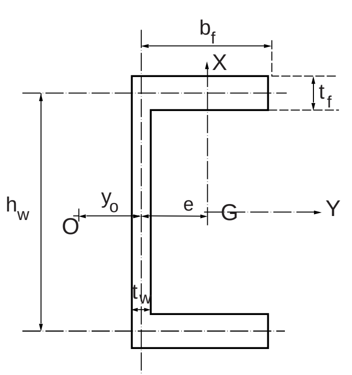
Cross-tie profile	e	y_0	J	I_W
T symmetrical 	0	0	$\frac{1}{3}(2b_f t_f^3 + h_w t_w^3)$	$\frac{t_f h_w^2 b_f^3}{24}$
T non-symmetrical 	0	0	$\frac{1}{3}\lvert(b_{1f} + b_{2f})t_f^3 + h_w t_w^3\rvert$	$\frac{t_f h_w^2 b_{1f}^3 b_{2f}^3}{12(b_{1f}^3 + b_{2f}^3)}$
Non-symmetrical 	$\frac{b^2 t_f}{h t_w + 2 b t_f}$	$\frac{3 b_f^2 t_f}{6 b_f t_f + h_w t_w}$	$\frac{1}{3}(2b_f t_f^3 + h_w t_w^3)$	$\frac{t_f b_f^3 h^2}{12} \frac{3 b_f t_f + 2 h_w t_w}{6 b_f t_f + h_w t_w}$

Table 3 : Welding factor w_F

Hull area	Connection		Welding factor w_F
	of	to	
Double bottom in way of cargo holds and tanks	girders	bottom and inner bottom plating	0,35
		floors (interrupted girders)	0,35
	floors	bottom and inner bottom plating	0,35
		inner bottom in way of lower stools, in general	0,45
		girders (interrupted floors)	0,35
Bulkheads in dry cargo holds	lower and upper stool structures	boundaries	0,45
	effective shedder plates (see [3.4.7])	vertical corrugations and lower stool top plate	One side penetration welding or equivalent
	effective gusset plates (see [3.4.8])	lower stool top plate	Full penetration welding
		vertical corrugations and shedder plates	One side penetration welding or equivalent
Bulkheads in oil cargo tanks	ordinary stiffeners	bulkhead plating	0,35

SECTION 4 MACHINERY AND CARGO SYSTEMS

1 General

1.1 Application

1.1.1 Ships having the service notation **combination carrier** are to comply with the requirements of Ch 7, Sec 4 applicable to oil tankers or oil tankers flashpoint > 60°C, as appropriate.

In addition, they are to comply with the provisions of this Section.

1.2 Documents

1.2.1 Documents to be submitted

In addition to those listed in Ch 7, Sec 4, Tab 2 the following documents are to be submitted for approval.

Table 1 : Documents to be submitted

Item N°	Description of the document **(1)**
1	Diagram of the ventilation systems serving cargo spaces and enclosed spaces adjacent to cargo spaces
2	Diagram of the gas measurement system for cargo pump rooms, pipe ducts and cofferdams adjacent to slop tanks
3	Diagram of water filling and draining systems for cofferdams
4	Diagram of discharge pumping and piping systems for slop tanks
(1) Diagrams are also to include, where applicable: • the (local and remote) control and monitoring systems and automation systems • the instructions for the operation and maintenance of the piping system concerned (for information).	

1.2.2 Instruction manual

A manual is to be kept on board giving all instructions for safe carriage of contaminated sludge in slop tanks when the ship is in the dry cargo mode.

2 General requirements

2.1 Ventilation and gas detection

2.1.1 Ventilation *(1/1/2007)*

All cargo spaces and any enclosed spaces adjacent to cargo spaces are to be capable of being mechanically ventilated. The mechanical ventilation may be provided by portable fans. See also Pt C, Ch 4, Sec 1, [5.2.2].

2.1.2 Gas detection *(1/1/2007)*

a) Arrangements for gas detection are to comply with the relevant provisions of Pt C, Ch 4, Sec 1, [5.2.4].

b) Audible and visual alarms for the gas detection equipment are to be located on the bridge or in other suitable continually manned spaces.

2.2 Arrangement of cargo lines

2.2.1 *(1/1/2007)*

a) Where cargo wing tanks are provided, cargo oil lines below deck are to be installed inside these tanks. However, the Society may permit cargo oil lines to be placed in special ducts which are to be capable of being adequately cleaned and ventilated and to the satisfaction of the Society.

   If connected to a cargo pump room, such ducts are to be considered as cargo pump rooms for the purposes of safety.

b) Where cargo wing tanks are not provided, cargo oil lines below deck are to be placed in special ducts.

2.3 Cargo openings

2.3.1 Openings which may be used for cargo operations are not permitted in bulkheads and decks separating oil cargo spaces from other spaces not designed and equipped for the carriage of oil cargoes unless alternative approved means are provided to ensure equivalent integrity.

2.4 Cofferdam filling and draining

2.4.1 Means are to be provided for filling the cofferdams surrounding the slop tanks with water and for draining them. See Sec 2, [2.1.3].

3 Slop tanks

3.1 Segregation of piping systems

3.1.1 *(1/1/2007)*

a) Pipes serving the slop tanks are to be segregated from other parts of the cargo pumping and piping system by means of isolation complying with b) or c) below.

b) Arrangements to isolate slop tanks containing oil or oil residues from other cargo tanks are to consist of blank flanges which are to remain in position at all times when cargoes other than oil products having a flashpoint not exceeding 60°C are carried.

c) Means are to be provided for isolating the piping connecting the pump room with the slop tanks. The means of isolation are to consist of a valve followed by a spectacle flange or a spool piece with appropriate blank flanges. This arrangement is to be located adjacent to the slop tanks, but where this is unreasonable or impracticable, it may be located within the pump room directly after the piping penetrates the bulkhead.

3.2 Venting system

3.2.1 Slop tanks are to be provided with a separate venting system complying with the provisions of Ch 7, Sec 4, [4.2].

3.3 Discharge pumping and piping arrangement

3.3.1 *(1/1/2007)*

A separate pumping and piping arrangement incorporating a manifold is to be provided for discharging the contents of the slop tanks directly to the open deck for disposal to shore reception facilities when the ship is in the dry cargo mode.

Part E
Service Notations

Chapter 7
OIL TANKERS AND FLS TANKERS

SECTION 1 GENERAL

1 General

1.1 Application

1.1.1 Service notation oil tanker *(1/7/2011)*

a) The requirements of this Chapter apply to ships having the service notations **oil tanker** or **oil tanker ESP**, as defined in Pt A, Ch 1, Sec 2, [4.5.2] and **oil tanker ESP CSR**, as defined in Pt A, Ch 1, Sec 2, [4.5.3] and **asphalt tanker**, as defined in Pt A, Ch 1, Sec 2, [4.5.8] or **asphalt tanker ESP** as defined in Pt A, Ch 1, Sec 2, [4.5.9]. They also apply to ships having the additional service feature **flash point > 60°C**, taking into account the departures given in the different Sections.

Note 1: The departures referred to in a) above do not apply to ships intended for the carriage of bulk cargoes at a temperature above the flashpoint of the product carried.

b) Additional departures are given for ships that have the service notation **oil tanker, flashpoint > 60°C** or **oil tanker ESP, flash point > 60°C** or **oil tanker ESP CSR, flash point > 60°C** and are intended only for the carriage of bulk cargoes:

- at a temperature below and not within 15°C of their flashpoint, or
- having a flashpoint above 100°C.

c) Sec 4, [8] provides additional requirements for ships having the servicenotation **asphalt tanker** or **asphalt tanker ESP**.

d) The list of substances the carriage in bulk of which is covered by the service notations

- **oil tanker**
- **oil tanker, flashpoint > 60°C**
- **oil tanker ESP**
- **oil tanker ESP CSR**
- **oil tanker ESP, flashpoint > 60°C**
- **oil tanker ESP CSR, flashpoint > 60°C**
- **asphalt tanker**
- **asphalt tanker ESP**

is given in App 3.

1.1.2 Service notation FLS tanker

a) The requirements of this Chapter apply to ships having the service notation **FLS tanker**, as defined in Pt A, Ch 1, Sec 2, [4.5.6]. They also apply to ships having the additional service feature **flash point > 60°C**, taking into account the departures given in Sec 4.

Note 1: The departures referred to in a) above do not apply to ships intended for the carriage of bulk cargoes at a temperature above the flashpoint of the product carried.

b) Sec 4, [8] provides additional requirements for ships having the service notations **FLS tanker** and **FLS tanker, flash point > 60°C** in the case of carriage of pollution category Z products.

c) The list of substances the carriage in bulk of which is covered by the service notations **FLS tanker** and **FLS tanker, flash point > 60°C** is given in App 4.

Note 2: The service notation **FLS tanker** does not cover cargoes containing 10% of benzene or more. Ships carrying such cargoes are to comply with the relevant requirements of Chapter 8.

Note 3: Where the provisions of this Chapter applicable to the service notation **oil tanker** and those applicable to the service notation **FLS tanker** are simultaneously complied with, a ship may be granted both service notations **oil tanker - FLS tanker** or **oil tanker - FLS tanker, flash point > 60°C**, as applicable.

1.2 Summary tables

1.2.1 *(1/7/2011)*

Tab 1 indicates, for easy reference, the Sections or Appendixes of this Chapter dealing with requirements applicable to ships having the following service notations:

- **oil tanker**
- **oil tanker, flashpoint > 60°C**
- **oil tanker ESP**
- **oil tanker ESP, flashpoint > 60°C**
- **FLS tanker**
- **FLS tanker, flashpoint > 60°C**
- **asphalt tanker**
- **asphalt tanker ESP**.

1.2.2 *(1/4/2006)*

Tab 2 indicates, for easy reference, the Sections or Appendixes of this Chapter dealing with requirements applicable to ships having the following service notations:

- **oil tanker ESP CSR**
- **oil tanker ESP CSR, flash point > 60°C**

Table 1 : Sections or Appendixes with requirements applicable to ships having the Service Notations indicated in [1.2.1] *(1/7/2011)*

Main subject	Reference
Ship arrangement	Sec 2
Hull and stability	Sec 3
Machinery and cargo system	Sec 4 and Sec 5
Electrical installations	Sec 6
Automation	**(1)**
Fire protection, detection and extinction	**(1)**
Devices to prevent the passage of flames into cargo tanks	App 1
Crude oil washing system	App 2
List of oils	App 3
List of easy chemicals	App 4
(1) No specific requirements are given in this Chapter.	

Table 2 : Sections or Appendixes with requirements applicable to ships having the Service Notations indicated in [1.2.2] *(1/7/2011)*

Main subject	Reference
Ship arrangement	Sec 2
Hull	**(1)**
Stability	Sec 3, [1]
Machinery and cargo system	Sec 4 and Sec 5
Electrical installations	Sec 6
Automation	**(1)**
Fire protection, detection and extinction	**(1)**
Devices to prevent the passage of flames into cargo tanks	App 1
Crude oil washing system	App 2
List of oils	App 3
(1) No specific requirement are given in this Chapter.	

1.3 Definitions

1.3.1 Cargo area

The cargo area is that part of the ship that contains cargo tanks as well as slop tanks, cargo pump rooms including pump rooms, cofferdams, ballast or void spaces adjacent to cargo tanks or slop tanks as well as deck areas throughout the entire length and breadth of the part of the ship above these spaces.

When independent tanks are installed in hold spaces, the cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forwardmost hold space are excluded from the cargo area.

1.3.2 Cargo pump room

Cargo pump room is a space containing pumps and their accessories for the handling of products covered by the service notation granted to the ship.

1.3.3 Cargo service spaces

Cargo service spaces are spaces within the cargo area used for workshops, lockers and storerooms of more than 2 m^2 in area, intended for cargo handling equipment.

1.3.4 Cargo tank block *(1/7/2017)*

Cargo tank block is the part of the ship as indicated in Fig 1, extending from the aft bulkhead of the aftmost cargo or slop tank to the forward bulkhead of the forward most cargo or slop tank, extending to the full depth and beam of the ship, but not including the area above the deck of the cargo or slop tank.

1.3.5 Clean ballast

Clean ballast means the ballast in a tank which since oil was last carried therein, has been so cleaned that the effluent therefrom if it were discharged from a ship which is stationary into clean calm water on a clear day would not produce visible traces of oil on the surface of the water or on adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines. If the ballast is discharged through an oil discharge monitoring and control system approved by the Society, evidence based on such a system to the effect that the oil content of the effluent did not exceed 15 parts per million is to be determinative that the ballast was clean, notwithstanding the presence of visible traces.

1.3.6 Crude oil

Crude oil means any liquid hydrocarbon mixture occurring naturally in the earth whether or not treated to render it suitable for transportation and includes:

a) crude oil from which certain distillate fractions have been removed, and
b) crude oil to which certain distillate fractions may have been added.

1.3.7 Crude oil tanker

Crude oil tanker means an oil tanker engaged in the trade of carrying crude oil.

1.3.8 Hold space

Hold space is the space enclosed by the ship's structure in which an independent cargo tank is fitted

1.3.9 Fuel oil

Fuel oil means any oil used as fuel in connection with the propulsion and auxiliary machinery of the ship on which such oil is carried.

1.3.10 Integrated cargo and ballast system *(1/1/2004)*

Integrated cargo and ballast system means any integrated hydraulic and/or electric system used to drive both cargo and ballast pumps (including active control and safety systems and excluding passive components, e.g. piping).

1.3.11 Oil mixture

Oil mixture means a mixture with any oil content.

1.3.12 Product carrier

Product carrier means an oil tanker engaged in the trade of carrying oil other than crude oil.

1.3.13 Pump room

Pump room is a space, located in the cargo area, containing pumps and their accessories for the handling of ballast and fuel oil, or cargoes other than those covered by the service notation granted to the ship.

1.3.14 Segregated ballast

Segregated ballast means the ballast water introduced into a tank which is completely separated from the cargo oil and fuel oil system and which is permanently allocated to the carriage of ballast or to the carriage of ballast or cargoes other than oil or noxious substances as variously defined in Chapter 7 and Chapter 8.

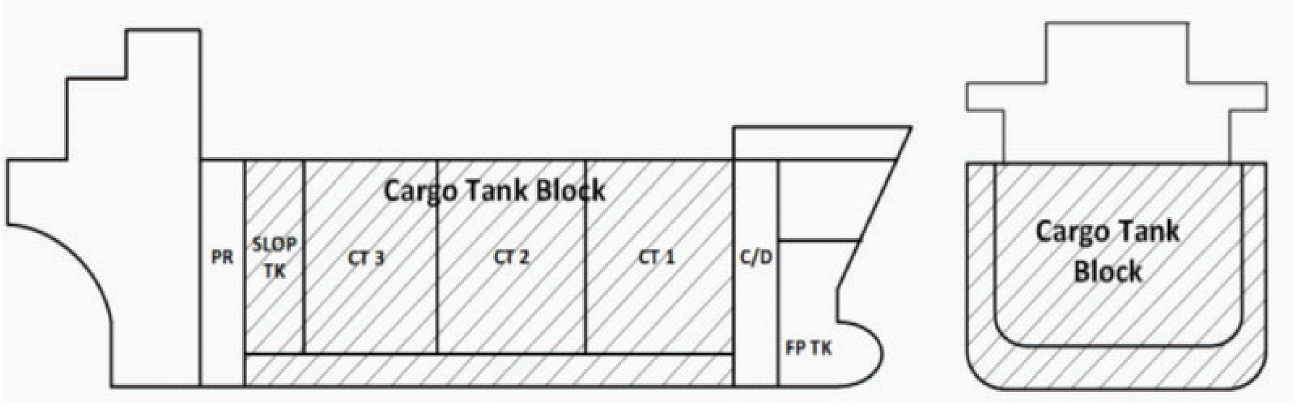
1.3.15 Slop tank

Slop tank means a tank specifically designated for the collection of tank draining, tank washings and other oily mixtures.

1.3.16 Void space

Void space is an enclosed space in the cargo area external to a cargo tank, except for a hold space, ballast space, fuel oil tank, cargo pump room, pump room, or any space normally used by personnel.

Figure 1 : Cargo tank block *(1/7/2017)*



SECTION 2 SHIP ARRANGEMENT

1 General

1.1 Application

1.1.1 *(1/7/2011)*

The requirements in Sec 2 apply to single deck ships, with machinery aft, double bottom throughout the cargo tank area, double side skin and possible longitudinal bulkheads, or single side skin and one or more longitudinal bulkheads throughout the cargo tank area. The deck may be single or double skin, with or without a trunk.

The application of these requirements to other ship types is to be considered by the Society on a case-by-case basis.

1.1.2 Deviations *(1/7/2011)*

The requirements in [2.1.2] to [2.1.4], apply only to ships with the service notations:

- **oil tanker ESP**
- **oil tanker ESP CSR**
- **FLS tanker**.

The requirements in [2.2], [3], [4] and [5] apply only to ships with the service notations:

- **oil tanker ESP**
- **oil tanker ESP CSR**
- **oil tanker ESP, flashpoint > 60°C**
- **oil tanker ESP CSR, flashpoint > 60°C**
- **asphalt tanker**
- **asphalt tanker ESP.**

The requirements in [6] apply only to ships with the service notations:

- **oil tanker ESP**
- **oil tanker ESP CSR**
- **oil tanker ESP, flashpoint > 60°C**
- **oil tanker ESP CSR, flashpoint > 60°C**
- **asphalt tanker**
- **asphalt tanker ESP**

apart from [6.2.2], which applies also to ships having the service notation **FLS tanker**.

2 General arrangement design

2.1 General

2.1.1 Specification

The requirements in [2.1.2] to [2.1.4] apply also to ships with the service notation FLS tanker.

2.1.2 Cofferdams

A cofferdam or similar compartment of width not less than 760 mm is to be provided at the aft end of the cargo tank area. Its bulkheads are to extend from keel to deck across the full breadth of the ship.

For the purpose of this requirement, the term "cofferdam" is intended to mean an isolating compartment between two adjacent steel bulkheads or decks. The minimum distance between the two bulkheads or decks is to be sufficient for safe access and inspection.

In order to meet the single failure principle, in the particular case when a corner-to-corner situation occurs, this principle may be met by welding a diagonal plate across the corner.

The cofferdams are also to be constructed so as to enable adequate ventilation.

2.1.3 Cargo segregation

Unless expressly provided otherwise, tanks containing cargo or cargo residues are to be segregated from accommodation, service and machinery spaces, drinking water and stores for human consumption by means of a cofferdam, or any other similar compartment.

Where accommodation and service compartments are arranged immediately above the compartments containing flammable liquids, the cofferdam may be omitted only where the deck is not provided with access openings and is coated with a layer of material recognised as suitable by the Society. The cofferdam may also be omitted where such compartments are adjacent to a passageway, subject to the following conditions:

- the thicknesses of common boundary plates of adjacent tanks are increased, with respect to those obtained from the applicable requirements in Part B and Sec 3, 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 such plates is not less than the thickness of the plates themselves
- the hydrostatic test is carried out with a head increased by 1 m with respect to that required in Pt B, Ch 12, Sec 3.

2.1.4 Deck spills

Means are to be provided to keep deck spills away from the accommodation and service areas. This may be accomplished by providing a permanent continuous coaming of a suitable height extending from side to side.

Where gutter bars are installed on the weather decks of oil tankers in way of cargo manifolds and are extended aft as far as the aft bulkhead of superstructures for the purpose of containing cargo spills on deck during loading and discharge operations, the free surface effects caused by containment of a cargo spill during liquid transfer operations or of boarding seas while underway are to be considered with respect to the vessel's available margin of positive initial stability (GM_o).

Where the gutter bars installed are higher than 300 mm, they are to be treated as bulwarks with freeing ports arranged in accordance with Pt B, Ch 9, Sec 9, [5] and effective closures provided for use during loading and discharge operations. Attached closures are to be arranged in such a way that jamming cannot occur while at sea, ensuring that the freeing ports will remain fully effective.

On ships without deck camber, or where the height of the installed gutter bars exceeds the camber, and for oil tankers having cargo tanks exceeding 60% of the vessel's maximum beam amidships regardless of gutter bar height, gutter bars may not be accepted without an assessment of the initial stability (GM_o) for compliance with the relevant intact stability requirements taking into account the free surface effect caused by liquids contained by the gutter bars.

2.1.5 Location of fuel tanks in cargo area *(1/7/2019)*

a) These requirements apply to oil tankers carrying liquid cargoes having a flashpoint not exceeding 60°C.

b) Fuel tanks located with a common boundary to cargo or slop tanks shall not be situated within nor extend partly into the cargo tank block. Such tanks may, however, be situated aft and/or forward of the cargo tank block.

c) They may be accepted when located as independent tanks on open deck in the cargo area subject to spill and fire safety considerations.

d) The arrangement of independent fuel tanks and associated fuel piping systems, including the pumps, can be as for fuel tanks and associated fuel piping systems located in the machinery spaces. For electrical equipment, requirements to hazardous area classification must however be met.

2.2 Double bottom tanks or compartments

2.2.1 General

Double bottom tanks adjacent to cargo tanks may not be used as fuel oil tanks.

2.2.2 Oil tankers of 5000 t deadweight and above *(1/7/2007)*

a) At any cross-section, the depth of each double bottom tank or compartment is to be such that the distance h between the bottom of the cargo tanks and the moulded line of the bottom shell plating measured at right angles to the bottom shell plating, as shown in Fig 1, is not less than B/15, in m, or 2,0 m, whichever is the lesser. h is to be not less than 1,0 m.

b) Double bottom tanks or compartments as required by a) may be dispensed with, provided that the design of the tanker is such that the cargo and vapour pressure exerted on the bottom shell plating forming a single boundary between the cargo and the sea does not exceed the external hydrostatic water pressure, as expressed by the following formula:

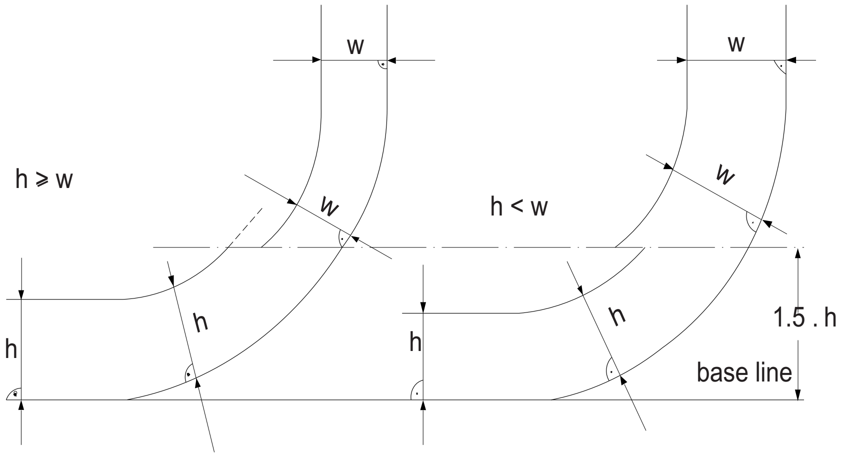
$$f h_c \rho_c g + 1000 \Delta p \le T_1 \rho g$$

where:

- f : *Safety factor equal to 1,1*
- h_c : *Height, in m, of cargo in contact with the bottom plating*
- ρ_c : *Maximum cargo density, in t/m³*
- g : *Standard acceleration of gravity equal to 9,81 m/s²*
- Δp : *Maximum set pressure, in MPa, of pressure/vacuum valve provided for the cargo tank*
- T_1 : *Minimum operating draught, in m, under any expected loading condition*
- ρ : *Density of sea water, in t/m³.*

c) Any horizontal partition necessary to fulfil the above requirements is to be located at a height not less than B/6 or 6 m, whichever is the lesser, but not more than 0,6D, above the baseline where D is the moulded depth amidships.

Figure 1 : Cargo tank boundary lines

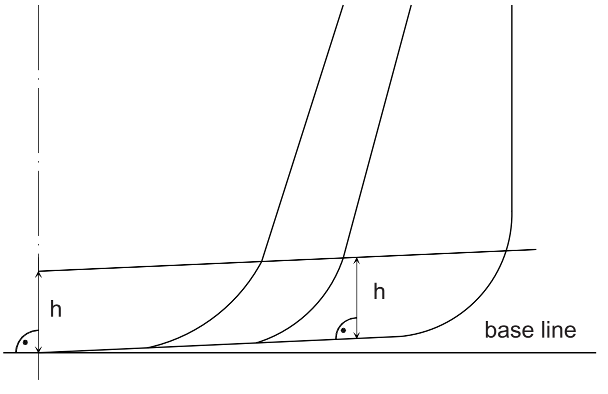


2.2.3 Oil tankers of less than 5000 t but at least 600 t deadweight

At any cross-section, the depth of each double bottom tank or compartment is to be such that the distance h between the bottom of the cargo tanks and the moulded line of the bottom shell plating measured at right angles to the bottom shell is not less than B/15, in m, with a minimum value of 0,76 m.

In the turn of the bilge area and at locations without a clearly defined turn of the bilge, the cargo tank boundary line is to run parallel to the line of the midship flat bottom as shown in Fig 2.

Figure 2 : Cargo tank boundary lines



2.3 Navigation position

2.3.1 When it is proven necessary to provide a navigation station above the cargo area, such station is to be for navigation purposes only and is to be separated from the cargo tank deck by an open space of at least 2 m in height.

3 Size and arrangement of cargo tanks and slop tanks

3.1 Cargo tanks

3.1.1 General

Oil tankers of 600 t deadweight and above are not allowed to carry oil in any compartment extending forward of a collision bulkhead located in accordance with Pt B, Ch 2, Sec 1, [2].

3.1.2 Oil tankers of 5000 t deadweight and above *(1/7/2007)*

Oil tankers of 5000 t deadweight and above are to comply with the requirements in [3.2].

3.1.3 Oil tankers of less than 5000 t *(1/7/2007)*

The length of each cargo tank is not to exceed 10 metres or one of the values of Tab 1, as applicable, whichever is the greater.

Oil tankers of less than 5000 t but at least 600 t deadweight are to be provided with cargo tanks so arranged that the capacity of each cargo tank does not exceed 700 m^3 unless wing tanks or compartments are arranged in accordance with [4.2.2] complying with the following:

$$w = 0,4 + \frac{2,4 DW}{20000} \quad \text{with a minimum value of 0,76 m}$$

where w is the distance, in m, as described in Fig 1 and DW is the deadweight, in t.

3.1.4 Piping through cargo tanks *(1/7/2007)*

Lines of piping which run through cargo tanks in a position less than 0,30 B_s from the ship's side or less than 0,30 D_s from the ship's bottom are to be fitted with valves or similar closing devices at the point at which they open into any cargo tank. These valves are to be kept closed at sea at any time when the tanks contain cargo oil, except that they may be opened only for cargo transfer needed for essential operations.

3.1.5 Suction wells in cargo tanks *(1/7/2007)*

Suction wells in cargo tanks may protrude into the double bottom below the boundary line defined by the distance h in [2.2.2] or [2.2.3], as applicable, provided that such wells are as small as practicable and the distance between the well bottom and bottom shell plating is not less than 0,5 h.

3.2 Oil outflow

3.2.1 Definitions *(1/7/2007)*

- *Load line draught d_S, in m*

  Vertical distance, in metres, from the moulded baseline at mid-length to the waterline corresponding to the summer freeboard to be assigned to the ship. Calculations pertaining to this requirement are to be based on draught d_S, notwithstanding assigned draughts that may exceed d_S, such as the tropical load line.

- *Waterline d_B, in m*

  Vertical distance, in metres, from the moulded baseline at mid-length to the waterline corresponding to 30% of the depth D_S.

- *Breadth B_S, in m*

  Greatest moulded breadth of the ship, in metres, at or below the deepest load line d_S.

- *Breadth B_B in m*

  Greatest moulded breadth of the ship, in metres, at or below the waterline d_B.

- *Depth D_S in m*

  Moulded depth measured at mid-length to the upper deck at side.

Table 1 : Length of cargo tanks

Longitudinal bulkhead arrangement	Cargo tank	Condition **(1)**	Centreline bulkhead arrangement	Length of cargo tanks, in m
No bulkhead	-	-	-	$(0,5\ b_i / B + 0,1)\ L$ **(2)**
Centreline bulkhead	-	-	-	$(0,25\ b_i / B + 0,15)\ L$
Two or more bulkheads	Wing cargo tank	-	-	0,2 L
	Centre cargo tank	$b_i / B \geq 1/5$	-	0,2 L
		$b_i / B < 1/5$	No	$(0,5\ b_i / B + 0,1)\ L$
			Yes	$(0,25\ b_i / B + 0,15)\ L$

(1) b_i is the minimum distance from the ship side to the outer longitudinal bulkhead of the i-th tank, measured inboard at right angles to the centreline at the level corresponding to the assigned summer freeboard.
(2) Not to exceed 0,2 L

3.2.2 Oil outflow requirements *(1/7/2007)*

To provide adequate protection against oil pollution in the event of collision or stranding. the following is to be complied with:

a) for oil tankers of 5000 tonnes deadweight (DW) and above, the mean oil outflow parameter is to be as follows:

$O_M \leq 0,015$ for $C \leq 200000\ m^3$

$O_M \leq 0,012 + (0,003/200000)\ (400000-C)$ for $200000\ m^3 < C < 400000\ m^3$

$O_M \leq 0,012$ for $C \geq 400000\ m^3$

b) for combination carriers between 5000 tonnes deadweight (DW) and 200000 m³ capacity, the mean oil outflow parameter may be applied, provided calculations are submitted to the satisfaction of the Society, demonstrating that after accounting for its increased structural strength, the combination carrier has at least equivalent oil outflow performance to a standard double hull tanker of the same size having a $O_M \leq 0,015$.

$O_M \leq 0,021$ for $C \leq 100000\ m^3$

$O_M \leq 0,015 + (0,006/100000)\ (200000-C)$ for $100000\ m^3 < C \leq 200000\ m^3$

where:

O_M : *mean oil outflow parameter.*

C : *total volume of cargo oil, in m³, at 98% tank filling.*

3.2.3 General assumptions for calculation of oil outflow parameter *(1/7/2007)*

The following general assumptions are to be applied when calculating the mean oil outflow parameter:

a) The cargo block length extends between the forward and aft extremities of all tanks arranged for the carriage of cargo oil, including slop tanks.

b) Where this requirement refers to cargo tanks, it is to be understood to include all cargo tanks, slop tanks and fuel tanks located within the cargo block length.

c) The ship is to be assumed loaded to the load line draught d_S without trim or heel.

d) All cargo oil tanks are to be assumed loaded to 98% of their volumetric capacity.

e) The nominal density of the cargo oil (ρ_n) is to be calculated as follows:

$\rho_n = 1000\ DW/C$, *where DW is the deadweight, in tonnes*

f) For the purposes of these outflow calculations, the permeability of each space within the cargo block, including cargo tanks, ballast tanks and other non-oil spaces, is to be taken as 0,99, unless proven otherwise.

g) Suction wells may be neglected in the determination of tank location provided that such wells are as small as practicable and the distance between the well bottom and bottom shell plating is not less than 0,5 h, where h is the height as defined in [2.2.2].

3.2.4 General assumptions for combination of oil outflow parameters *(1/7/2007)*

The following assumptions are to be used when combining the oil outflow parameters:

The mean oil outflow is to be calculated independently for side damage and for bottom damage and then combined into the non-dimensional oil outflow parameter O_M, as follows:

$$O_M = (0,4\ O_{MS} + 0,6\ O_{MB}) / C$$

where:

O_{MS} : *mean outflow for side damage, in m³;*

O_{MB} : *mean outflow for bottom damage, in m³.*

For bottom damage, independent calculations for mean outflow are to be done for 0 m and minus 2,5 m tide conditions, and then combined as follows:

$$O_{MB} = 0,7\ O_{MB(0)} + 0,3\ O_{MB(2,5)}$$

where:

$O_{MB(0)}$: *mean outflow for 0 m tide condition, in m³*

$O_{MB(2,5)}$: *mean outflow for minus 2,5 m tide condition, in m³.*

3.2.5 Calculation of side damage outflow *(1/7/2007)*

The mean outflow for side damage O_{MS}, in m^3, is to be calculated as follows:

$$O_{MS} = C_3 \sum_i^n P_{s(i)} O_{s(i)}$$

where:

- *i* : *represents each cargo tank under consideration;*
- *n* : *total number of cargo tanks;*
- $P_{s(i)}$: *the probability of penetrating cargo tank i from side damage, calculated in accordance with [3.2.7];*
- $O_{s(i)}$: *the outflow, in m^3, from side damage to cargo tank i, which is assumed equal to the total volume in cargo tank i at 98% filling, unless it is proven through the application of the IMO Resolution referred to in [4.2.6] that any significant cargo volume will be retained;*
- C_3 : *0,77 for ships having two longitudinal bulkheads inside the cargo tanks, provided these bulkheads are continuous over the cargo block and $P_{s(i)}$ is developed in accordance with this requirement. C_3 equals 1,0 for all other ships or when $P_{s(i)}$ is developed in accordance with [3.2.7].*

3.2.6 Calculation of bottom damage outflow *(1/7/2017)*

The mean outflow for bottom damage, in m^3, is to be calculated for each tidal condition as follows:

a)

$$O_{MB(0)} = \sum_i^n P_{B(i)} O_{B(i)} C_{DB(i)}$$

where:

- *i* : *represents each cargo tank under consideration;*
- *n* : *total number of cargo tanks;*
- $P_{B(i)}$: *the probability of penetrating cargo tank i from bottom damage, calculated in accordance with [3.2.8];*
- $O_{B(i)}$: *the outflow from cargo tank i, in m^3, calculated in accordance with c);*
- $C_{DB(i)}$: *factor to account for oil capture as defined in d)*

b)

$$O_{MB(2,5)} = \sum_i^n P_{B(i)} O_{B(i)} C_{DB(i)}$$

where:

i, n, $P_{B(i)}$ and $C_{DB(i)}$ as defined above;

$O_{B(i)}$ = the outflow from cargo tank i, in m^3, after tidal change.

c) The oil outflow $O_{B(i)}$ for each cargo oil tank is to be calculated based on pressure balance principles, in accordance with the following assumptions:

- *The ship is to be assumed stranded with zero trim and heel, with the stranded draught prior to tidal change equal to the load line draught d_s.*
- *The cargo level after damage is to be calculated as follows:*

  $h_c = [(d_s + t_c - Z_l) (\rho_s) - (1000 P) / g] / \rho_n$

  where:

  - h_c : *the height of the cargo oil above Z_l, in m;*
  - t_c : *the tidal change, in m. Reductions in tide are to be expressed as negative values;*
  - Z_l : *the height of the lowest point in the cargo tank above the baseline, in m;*
  - ρ_s : *density of seawater, to be taken as 1025 kg/m^3;*
  - *P* : *if an inert gas system is fitted, the normal overpressure, in kPa, is to be taken as 5 kPa; if an inert gas system is not fitted, the overpressure may be taken as 0;*
  - *g* : *the acceleration of gravity, to be taken as 9,81 m/s^2;*
  - ρ_n : *nominal density of cargo oil, calculated in accordance with [3.2.3].*
- *For cargo tanks bounded by the bottom shell, unless proven otherwise, oil outflow $O_{B(i)}$ is to be taken not less than 1% of the total volume of cargo oil loaded in cargo tank i, to account for initial exchange losses and dynamic effects due to current and waves.*

d) In the case of bottom damage, a portion from the outflow from a cargo tank may be captured by non-oil compartments. This effect is approximated by application of the factor $C_{DB(i)}$ for each tank, which is to be taken as follows:

- $C_{DB(i)}$: *0,6 for cargo tanks bounded from below by non-oil compartments;*
- $C_{DB(i)}$: *1,0 for cargo tanks bounded by the bottom shell.*

3.2.7 Calculation of probability for side damage *(1/7/2007)*

The probability P_S of breaching a compartment from side damage is to be calculated as follows:

a) $P_S = P_{SL} P_{SV} P_{ST}$

where:

$P_{SL} = 1 - P_{Sf} - P_{Sa}$ = probability the damage will extend into the longitudinal zone bounded by X_a and X_f;

$P_{SV} = 1 - P_{Su} - P_{Sl}$ = probability the damage will extend into the vertical zone bounded by Z_l and Z_u; and

$P_{ST} = 1 - P_{Sy}$ = probability the damage will extend transversely beyond the boundary defined by y.

b) P_{Sa}, P_{Sf}, P_{Sl}, P_{Su} and P_{Sy} are to be determined by linear interpolation from the table of probabilities for side damage provided in Tab 2, *where:*

P_{Sa} : *the probability the damage will lie entirely aft of location X_a/L;*

P_{Sf} : *the probability the damage will lie entirely forward of location X_f/L;*

P_{Sl} : *the probability the damage will lie entirely below the tank;*

P_{Su} : *the probability the damage will lie entirely above the tank; and*

P_{Sy} : *the probability the damage will lie entirely outboard of the tank.*

Compartment boundaries X_a, X_f, Z_l, Z_u and y are to be developed as follows:

X_a : *the longitudinal distance from the aft terminal of L to the aftmost point on the compartment being considered, in m;*

X_f : *the longitudinal distance from the aft terminal of L to the foremost point on the compartment being considered, in m;*

Z_l : *the vertical distance from the moulded baseline to the lowest point on the compartment being considered, in m;*

Z_u : *the vertical distance from the moulded baseline to the highest point on the compartment being considered, in m. Z_u is not to be taken greater than D_s;*

y : *the minimum horizontal distance measured at right angles to the centreline between the compartment under consideration and the side shell in m;*

c) *P_{Sy} is to be calculated as follows:*

$P_{Sy} = (24,96 - 199,6\ y/B_S)\ (y/B_S)$ *for* $y/B_S \leq 0,05$

$P_{Sy} = 0,749 + [5 - 44,4\ (y/B_S - 0,05)]\ (y/B_S - 0,05)$ *for* $0,05 < y/B_S < 0,1$

$P_{Sy} = 0,888 + 0,56\ (y/B_S - 0,1)$ *for* $y/B_S \geq 0,1$

P_{Sy} is not to be taken greater than 1.

Table 2 : Probabilities for side damage *(1/7/2007)*

X_a/L	P_{Sa}	X_f/L	P_{Sf}	Z_l/D_S	P_{Sl}	Z_u/D_S	P_{Su}
0,00	0,000	0,00	0,967	0,00	0,000	0,00	0,968
0,05	0,023	0,05	0,917	0,05	0,000	0,05	0,952
0,10	0,068	0,10	0,867	0,10	0,001	0,10	0,931
0,15	0,117	0,15	0,817	0,15	0,003	0,15	0,905
0,20	0,167	0,20	0,767	0,20	0,007	0,20	0,873
0,25	0,217	0,25	0,717	0,25	0,013	0,25	0,836
0,30	0,267	0,30	0,667	0,30	0,021	0,30	0,789
0,35	0,317	0,35	0,617	0,35	0,034	0,35	0,733
0,40	0,367	0,40	0,567	0,40	0,055	0,40	0,670
0,45	0,417	0,45	0,517	0,45	0,085	0,45	0,599
0,50	0,467	0,50	0,467	0,50	0,123	0,50	0,525
0,55	0,517	0,55	0,417	0,55	0,172	0,55	0,452
0,60	0,567	0,60	0,367	0,60	0,226	0,60	0,383
0,65	0,617	0,65	0,317	0,65	0,285	0,65	0,317
0,70	0,667	0,70	0,267	0,70	0,347	0,70	0,255
0,75	0,717	0,75	0,217	0,75	0,413	0,75	0,197
0,80	0,767	0,80	0,167	0,80	0,482	0,80	0,143
0,85	0,817	0,85	0,117	0,85	0,553	0,85	0,092
0,90	0,867	0,90	0,068	0,90	0,626	0,90	0,046
0,95	0,917	0,95	0,023	0,95	0,700	0,95	0,013
1,00	0,967	1,00	0,000	1,00	0,775	1,00	0,000

3.2.8 Calculation of probability for bottom damage *(1/7/2007)*

a) *The probability P_B of breaching a compartment from bottom damage is to be calculated as follows:*

$P_B = P_{BL} P_{BT} P_{BV}$

where:

$P_{BL} = 1 - P_{Bf} - P_{Ba}$ = *probability the damage will extend into the longitudinal zone bounded by X_a and X_f*

$P_{BT} = 1 - P_{Bp} - P_{Bs}$ = *probability the damage will extend into the transverse zone bounded by Y_p and Y_s*

$P_{BV} = 1 - P_{Bz}$ = *probability the damage will extend vertically above the boundary defined by z*

b) *P_{Ba}, P_{Bf}, P_{Bp}, P_{Bs}, and P_{Bz} are to be determined by linear interpolation from the table of probabilities for bottom damage provided in Tab 3, where:*

P_{Ba} : *the probability the damage will lie entirely aft of location X_a/L;*

P_{Bf} : *the probability the damage will lie entirely forward of location X_f/L;*

P_{Bp} : *the probability the damage will lie entirely to port of the tank;*

P_{Bs} : *the probability the damage will lie entirely to starboard of the tank;*

P_{Bz} : *the probability the damage will lie entirely below the tank.*

Compartment boundaries X_a, X_f, Y_p, Y_s, and z are to be developed as follows:

X_a and X_f are as defined in [3.2.7];

Y_p : *the transverse distance from the port-most point on the compartment located at or below the waterline d_B, to a vertical plane located B_B /2 to starboard of the ship's centreline, in metres;*

Y_s : *the transverse distance from the starboard-most point on the compartment located at or below the waterline d_B, to a vertical plane located B_B /2 to starboard of the ship's centreline, in metres;*

z : *the minimum value of z over the length of the compartment, where, at any given longitudinal location, z is the vertical distance from the lower point of the bottom shell at that longitudinal location to the lower point of the compartment at that longitudinal location, in metres.*

Table 3 : Probabilities for bottom damage*(1/7/2007)*

X_a/L	P_{Ba}	X_f/L	P_{Bf}	Y_p/B_B	P_{Bp}	Y_s/B_B	P_{Bs}
0,00	0,000	0,00	0,969	0,00	0,844	0,00	0,000
0,05	0,002	0,05	0,953	0,05	0,794	0,05	0,009
0,10	0,008	0,10	0,936	0,10	0,744	0,10	0,032
0,15	0,017	0,15	0,916	0,15	0,694	0,15	0,063
0,20	0,029	0,20	0,894	0,20	0,644	0,20	0,097
0,25	0,042	0,25	0,870	0,25	0,594	0,25	0,133
0,30	0,058	0,30	0,842	0,30	0,544	0,30	0,171
0,35	0,076	0,35	0,810	0,35	0,494	0,35	0,211
0,40	0,096	0,40	0,775	0,40	0,444	0,40	0,253
0,45	0,119	0,45	0,734	0,45	0,394	0,45	0,297
0,50	0,143	0,50	0,687	0,50	0,344	0,50	0,344
0,55	0,171	0,55	0,630	0,55	0,297	0,55	0,394
0,60	0,203	0,60	0,563	0,60	0,253	0,60	0,444
0,65	0,242	0,65	0,489	0,65	0,211	0,65	0,494
0,70	0,289	0,70	0,413	0,70	0,171	0,70	0,544
0,75	0,344	0,75	0,333	0,75	0,133	0,75	0,594
0,80	0,409	0,80	0,252	0,80	0,097	0,80	0,644
0,85	0,482	0,85	0,170	0,85	0,063	0,85	0,694
0,90	0,565	0,90	0,089	0,90	0,032	0,90	0,744
0,95	0,658	0,95	0,026	0,95	0,009	0,95	0,794
1,00	0,761	1,00	0,000	1,00	0,000	1,00	0,844

c) P_{Bz} is to be calculated as follows:

$P_{Bz} = (14,5 - 67\ z/D_S)\ (z/D_S)$ for $z/D_S \leq 0,1$

$P_{Bz} = 0,78 + 1,1\ (z/D_S - 0,1)$ for $z/D_S > 0,1$

P_{Bz} is not to be taken greater than 1.

3.2.9 Alternative calculation procedures *(1/7/2007)*

This requirement uses a simplified probabilistic approach where a summation is carried out over the contributions to the mean outflow from each cargo tank. For certain designs such as those characterised by the occurrence of steps/recesses in bulkheads/decks and for sloping bulkheads and/or a pronounced hull curvature, more rigorous calculations may be appropriate. In such cases one of the following calculation procedures may be applied:

- *The probabilities referred to in [3.2.7] and [3.2.8] may be calculated with more precision through application of hypothetical sub-compartments.*
- *The probabilities referred to in [3.2.7] and [3.2.8] may be calculated through direct application of the probability density functions contained in the IMO Resolutions referred to in [4.2.6].*
- *The oil outflow performance may be evaluated in accordance with the method described in the IMO Resolutions referred to in [4.2.6].*

3.2.10 Credit for reducing oil outflow *(1/7/2007)*

Credit for reducing oil outflow through the use of an emergency rapid cargo transfer system or other system arranged to mitigate oil outflow in the event of an accident may be taken into account only after the effectiveness and safety aspects of the system are approved by the Society. Submittal for approval is to be made in accordance with the provisions of the IMO Resolutions referred to in [4.2.6].

3.3 Slop tanks

3.3.1 Oil tankers of 150 gross tonnage and above

The arrangements of the slop tank or combination of slop tanks are to have a capacity necessary to retain the slop generated by tank washings, oil residues and dirty ballast residues. The total capacity of the slop tank or tanks is to be not less than 3 per cent of the oil carrying capacity of the ships, except that the Society may accept:

- *2% for such oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for ejectors, without the introduction of additional water into the system*
- *2% where segregated ballast tanks are provided in accordance with [5]. This capacity may be further reduced to 1,5% for such oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for ejectors, without the introduction of additional water into the system.*

3.3.2 Oil tankers of 70000 t deadweight and above

Oil tankers of 70000 t deadweight and above are to be provided with at least two slop tanks.

4 Size and arrangement of protective ballast tanks or compartments

4.1 General

4.1.1 This requirement applies to oil tankers of 600 t deadweight and above.

4.2 Size and arrangement of ballast tanks or compartments

4.2.1 General

The entire cargo tank length is to be protected by ballast tanks or compartments other than cargo and fuel oil tanks as indicated in [4.2.2] to [4.2.6] for oil tankers of 5000 t deadweight and above, or [4.2.7] for oil tankers less than 5000 t deadweight.

4.2.2 Wing tanks or compartments

Wing tanks or compartments are to extend either for the full depth of the ship side or from the top of the double bottom to the uppermost deck, disregarding a rounded gunwale where fitted. They are to be arranged such that the cargo tanks are located inboard of the moulded line of the side shell plating, nowhere less than the distance w which, as shown in Fig 1, is measured at any cross-section at right angles to the side shell, as specified below:

- *$w = 0,5 + DW / 20000$, or*
- *$w = 2,0$ m*

whichever is the lesser.

The value of w is to be at least 1,0 m.

4.2.3 Wing tanks or compartments of oil tankers complying with 2.2.2 b)

The location of wing tanks or compartments of oil tankers of 5000 t deadweight and above which are exempted from the requirements of [2.2.2] a) is to be as defined in [4.2.2], except that, below a level 1,5 h above the baseline where h is as defined in [2.2.2] a), the cargo tank boundary line may be vertical down to the bottom plating, as shown in Fig 3.

Such wing tanks or compartments may not contain cargo or fuel oil.

4.2.4 Double bottom tanks or compartments

The requirements of [2.2.1] and [2.2.2] apply.

4.2.5 Aggregate capacity of ballast tanks

On crude oil tankers of 20000 t deadweight and above and product carriers of 30000 t deadweight and above, the aggregate capacity of wing tanks, double bottom tanks, forepeak tanks and afterpeak tanks is to be not less than the capacity of segregated ballast tanks necessary to meet the requirements of [5]. Wing tanks or compartments and double bottom tanks used to meet the requirements of [5] are to be located as uniformly as practicable along the cargo tank length. Additional segregated ballast capacity provided for reducing longitudinal hull girder bending stress, trim, etc., may be located anywhere within the ship.

In calculating the aggregate capacity, the following is to be taken into account:

- *the capacity of engine room ballast tanks is to be excluded from the aggregate capacity of ballast tanks*
- *the capacity of ballast tanks located inboard of double hull is to be excluded from the aggregate capacity of ballast tanks (see Fig 4).*

Any ballast carried in localised inboard extensions, indentation or recesses of the double hull, such as bulkhead stools, may be considered as *excess ballast above the minimum requirement for segregated ballast capacity according to [5].*

Figure 3 : Cargo tank boundary lines

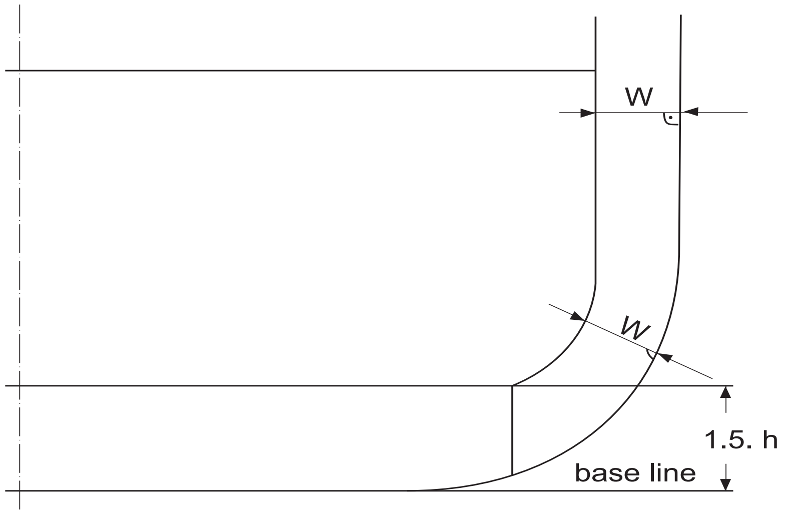
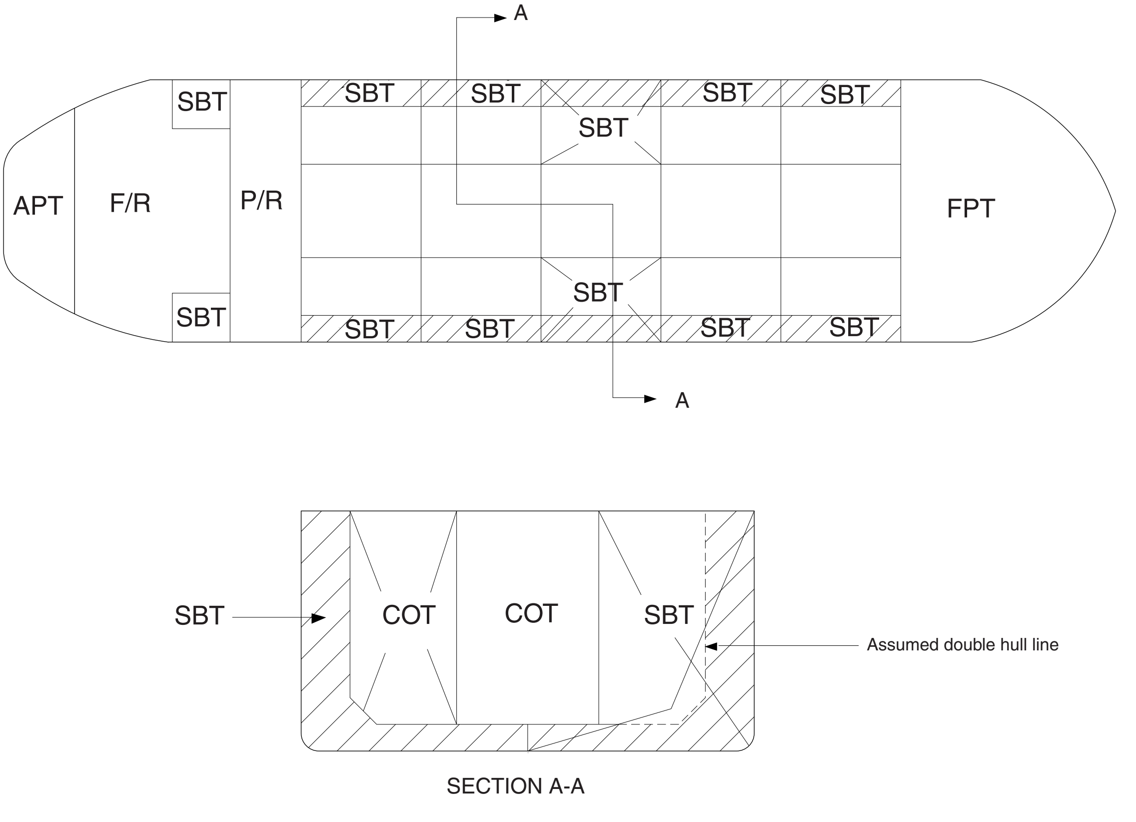


***Figure 4 :* Segregated ballast tanks located inboard of double hull**



4.2.6 Alternative methods of design and construction *(1/7/2007)*

Other methods of design and construction of oil tankers may also be accepted as alternatives to the requirements prescribed in [4.2.2] to [4.2.5], provided that such methods ensure at least the same level of protection against oil pollution in the event of collision or stranding. Such methods are to be accepted by the Society.

Note 1: The Society considers the method described in IMO Resolution MEPC.110(49) as being acceptable.

4.2.7 Oil tankers of less than 5000 t deadweight

Oil tankers of less than 5000 t deadweight are to comply with [2.2.3] and [3.1.3].

5 Size and arrangement of segregated ballast tanks (SBT)

5.1 General

5.1.1 *Every crude oil tanker of 20000 t deadweight and above and every product carrier of 30000 t deadweight and above is to be provided with segregated ballast tanks and is to comply with [5.2] or [5.3], as appropriate.*

5.2 Capacity of SBT for oil tankers equal to or greater than 150 m in length

5.2.1 *The capacity of the segregated ballast tanks is to be so determined that the ship may operate safely on ballast voyages without recourse to the use of cargo tanks for water ballast. In all cases, however, the capacity of segregated ballast tanks is to be at least such that, in any ballast condition at any part of the voyage, including the conditions consisting of lightweight plus segregated ballast only, the ship's draughts and trim can meet each of the following requirements:*

- *the moulded draught amidships, d_m in metres (without taking into account any ship's deformation) is to be not less than 2,0 + 0,02 L*
- *the draughts at the forward and after perpendicular are to correspond to those determined by the draught amidships d_m as specified above, in association with the trim by the stern of not greater than 0,015L*
- *in any case the draught at the after perpendicular is to be not less than that which is necessary to obtain full immersion of the propeller(s)*
- *in no case is ballast water to be carried in cargo tanks, except:*
  - *on those rare voyages when weather conditions are so severe that, in the opinion of the Master, it is necessary to carry additional ballast water in cargo tanks for the safety of the ship*
  - *in exceptional cases where the particular character of the operation of an oil tanker renders it necessary to carry ballast water in excess of the quantity required to comply with the requirements above, provided that such operation of the oil tanker falls under the category of exceptional cases.*

5.3 Capacity of SBT for oil tankers less than 150 m in length

5.3.1 General

The capacity of the segregated ballast tanks is to be considered by the Society on a case-by-case basis. In general, the capacity of segregated ballast tanks is to be at least such that, in any ballast condition at any part of the voyage, including the conditions consisting of lightweight plus segregated ballast only, the ship's draught and trim satisfy the requirements on minimum and maximum values given, as guidance only, in [5.3.2], [5.3.3] and [5.3.4]. These values are the results of different formulations.

The formulations are based both on theoretical research and surveys of actual practice on tankers of differing configuration reflecting varying degrees of concern with propeller emergence, vibration, slamming, speed loss, rolling, docking and other matters. In addition, certain information concerning assumed sea conditions is included.

5.3.2 Formulation A

The following formulae were derived from a study of 26 tankers ranging in length from 50 to 150 m. The draughts were abstracted from ship's trim and stability books and represent departure ballast conditions. The ballast conditions represent sailing conditions in weather up to and including Beaufort 5.

The minimum mean draught, in m, and the maximum trim, in m, are obtained from the following formulae, respectively:

$d_m = 0,2 + 0,032\ L$

$t_m = (0,024 - 6,0.10^{-5}L)\ L$

5.3.3 Formulation B

The following formulae result from investigations based on theoretical research, and model and full scale tests. These formulae are based on a Sea 6 (International Sea Scale).

The minimum draughts, in m, at stern and at bow are obtained from the following formulae, respectively:

$d_{m,S} = 2,3 + 0,030\ L$

$d_{m,B} = 0,7 + 0,0170\ L$

or the minimum mean draught, in m, and the maximum trim, in m, are obtained from the following formulae, respectively:

$d_m = 1,55 + 0,023\ L$

$t_m = 1,6 + 0,013\ L$

5.3.4 Formulation C

The following formulae provide for certain increased draughts to aid in the prevention of propeller emergence and slamming in higher length ships.

The minimum draughts, in m, at stern and at bow are obtained from the following formulae, respectively:

$d_{m,S} = 2,0 + 0,0275\ L$

$d_{m,B} = 0,5 + 0,0225\ L$

6 Access arrangement

6.1 General

6.1.1 As far as practicable, permanent or movable means of access stored on board are to be provided to ensure proper survey and maintenance of cargo tanks and ballast compartments.

6.1.2 Means of access to side and centre tanks may not be provided in the same transverse section.

6.2 Access to pipe tunnel and opening arrangement

6.2.1 Access to the pipe tunnel in the double bottom

The pipe tunnel in the double bottom is to comply with the following requirements:

- it may not communicate with the engine room
- provision is to be made for at least two exits to the open deck arranged at a maximum distance from each other. One of these exits fitted with a watertight closure may lead to the cargo pump room.

6.2.2 Doors between pipe tunnel and main pump room

This requirement also applies to ships with the service notation **FLS tanker**.

Where there is a permanent access from a pipe tunnel to the main pump room, a watertight door is to be fitted complying with the requirements in Pt B, Ch 2, Sec 1, [6.2.1] for watertight doors open at sea and located below the freeboard deck. In addition the following is to be complied with:

- *in addition to bridge operation, the watertight door is to be capable of being manually closed from outside the main pump room entrance*
- *the watertight door is to be kept closed during normal operations of the ship except when access to the pipe tunnel is required.* A notice is to be affixed to the door to the effect that it may not be left open.

6.3 Access to compartments in the cargo area

6.3.1 General

Access to cofferdams, ballast tanks, cargo tanks and other compartments in the cargo area is to be direct from the open deck and such as to ensure their complete inspection. Access to double bottom compartments may be through a cargo pump room, pump room, deep cofferdam, pipe tunnel or similar compartments, subject to consideration of ventilation aspects.

6.3.2 Access to the fore peak tank *(1/1/2012)*

The access to the fore peak tank is to be direct from the open deck.

Alternatively, indirect access from the open deck to the fore peak tank through an enclosed space may be accepted provided that:

a) if the enclosed space is separated from the cargo tanks by cofferdams, the access is through a gas-tight bolted manhole located in the enclosed space and a warning sign is provided at the manhole stating that the fore peak tank may only be opened after:
   - it has been proven to be gas-free; or
   - any electrical equipment which is not electrically certified safe in the enclosed space is isolated

b) if the enclosed space has a common boundary with the cargo tanks and is therefore a hazardous area (see Note 1), the enclosed space can be well ventilated.

Note 1: The hazardous area classification is to be defined in accordance with IEC 60092-502: Electrical installations in ships - Tankers - Special features.

6.3.3 Access through horizontal openings

For access through horizontal openings the dimensions are to be sufficient to allow a person wearing a self-contained, air-breathing apparatus and protective equipment to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the compartment. The minimum clear opening is to be not less than 600 mm by 600 mm.

6.3.4 Access through vertical openings

For access through vertical openings the minimum clear opening is to be not less than 600 mm by 800 mm at a height of not more than 600 mm from the bottom shell plating unless gratings or other footholds are provided.

6.3.5 Oil tankers less than 5000 t deadweight

For oil tankers of less than 5000 t deadweight smaller dimensions may be approved by the Society in special circumstances, if the ability to traverse such openings or to remove an injured person can be proved to the satisfaction of the Society.

6.4 Access to the bow

6.4.1 *(1/7/2008)*

This item [6.4] applies to ships subject to the International Load Line Convention 1966, as amended.

6.4.2 Oil tankers are to be provided either with a gangway between the superstructure or deckhouse aft and the forecastle, or with equivalent arrangements in accordance with the International Load Line Convention 1966, as amended.

6.4.3 *Oil tankers are to be provided with the means to enable the crew to gain safe access to the bow even in severe weather conditions. Such means are to be accepted by the Society.*

Note 1: The Society considers means in compliance with the Guidelines adopted by the Maritime Safety Committee of IMO with Resolution MSC.62(67) on 5/12/1996 as being acceptable.

SECTION 3 HULL AND STABILITY

Symbols

R_y : Minimum yield stress, in N/mm², of the material, to be taken equal to 235/k N/mm², unless otherwise specified

k : Material factor for steel, defined in Pt B, Ch 4, Sec 1, [2.3]

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

- E = 2,06.10⁵ N/mm² for steels in general
- E = 1,95.10⁵ N/mm² for stainless steels.

1 Stability

1.1 Application

1.1.1 The requirements in [1.2.2] apply only to ships with the service notation **oil tanker ESP**.

1.2 Intact stability

1.2.1 General

The stability of the ship for the loading conditions in Pt B, Ch 3, App 2, [1.2.6] is to be in compliance with the requirements in Pt B, Ch 3, Sec 2. In addition, the requirements in [1.2.2] are to be complied with.

1.2.2 Liquid transfer operations

Ships with certain internal subdivision may be subjected to lolling during liquid transfer operations such as loading, unloading or ballasting. In order to prevent the effect of lolling, the design of oil tankers of 5000 t deadweight and above is to be such that the following criteria are complied with*:*

a) *The intact stability criteria reported in b) is to be complied with for* the worst possible condition of loading and ballasting as defined in c)*, consistent with good operational practice, including the intermediate stages of liquid transfer operations. Under all conditions the ballast tanks are to be assumed slack.*

b) *The initial metacentric height GMo, in m, corrected for free surface measured at 0° heel, is to be not less than 0,15. For the purpose of calculating GMo, liquid surface corrections are to be based on the appropriate upright free surface inertia moment.*

c) *The vessel is to be loaded with:*

- *all cargo tanks filled to a level corresponding to the maximum combined total of vertical moment of volume plus free surface inertia moment at 0° heel, for each individual tank*
- *cargo density corresponding to the available cargo deadweight at the displacement at which transverse KM reaches a minimum value*
- *full departure consumable*
- *1% of the total water ballast capacity.The maximum free surface moment is to be assumed in all ballast tanks.*

2 Structure design principles

2.1 Framing arrangement

2.1.1 In general, within the cargo tank region of ships of more than 90 m in length, the bottom, the inner bottom and the deck are to be longitudinally framed.

Different framing arrangements are to be considered by the Society on a case-by-case basis, provided that they are supported by direct calculations.

2.2 Bulkhead structural arrangement

2.2.1 General

Transverse bulkheads may be either plane or corrugated.

2.2.2 Corrugated bulkheads *(1/7/2002)*

For ships of less than 120 m in length, vertically corrugated transverse or longitudinal bulkheads may be connected to the double bottom and deck plating.

For ships equal to or greater than 120 m in length, a lower and an upper stool are generally to be fitted. Different arrangements may be considered by the Society on a case-by-case basis, provided that they are supported by direct calculations carried out according to Pt B, Ch 7, Sec 3. These calculations are to investigate, in particular, the zones of connection of the bulkhead with innert bottom and deck plating and are to be submitted to the Society for review.

3 Design loads

3.1 Hull girder loads

3.1.1 Still water loads

In addition to the requirements in Pt B, Ch 5, Sec 2, [2.1.2], still water loads are to be calculated for the following loading conditions, subdivided into departure and arrival conditions as appropriate:

- homogeneous loading conditions (excluding tanks intended exclusively for segregated ballast tanks) at maximum draft
- partial loading conditions
- any specified non-homogeneous loading condition
- light and heavy ballast conditions
- mid-voyage conditions relating to tank cleaning or other operations where, at the Society's discretion, these differ significantly from the ballast conditions.

3.2 Local loads

3.2.1 Bottom impact pressure

For oil tankers of 20000 t deadweight and above and product carriers of 30000 t deadweight and above, the draught T_F, to be considered in the calculation of the bottom impact pressure according to Pt B, Ch 9, Sec 1, [3.2], is that calculated by using the segregated ballast tanks only.

3.2.2 Cargo mass density

In the absence of more precise values, a cargo mass density of 0,9 t/m^3 is to be considered for calculating the internal pressures and forces in cargo tanks according to Pt B, Ch 5, Sec 6.

4 Hull scantlings

4.1 Plating

4.1.1 Minimum net thicknesses *(1/7/2002)*

The net thickness of the strength deck and bulkhead plating within or bounding the longitudinal extension of the cargo area is to be not less than the values given in Tab 1.

4.2 Ordinary stiffeners

4.2.1 Minimum net thicknesses

The net thickness of the web of ordinary stiffeners is to be not less than the value obtained, in mm, from the following formulae:

$t_{MIN} = 0,75\, L^{1/3} k^{1/6} + 4,5\, s$ for $L < 275$ m

$t_{MIN} = 1,5\, k^{1/2} + 7,0 + s$ for $L \geq 275$ m

where s is the spacing, in m, of ordinary stiffeners.

4.3 Primary supporting members

4.3.1 Minimum net thicknesses

The net thickness of plating which forms the webs of primary supporting members is to be not less than the value obtained, in mm, from the following formula:

$t_{MIN} = 1,45\, L^{1/3} k^{1/6}$

4.3.2 Loading conditions for the analyses of primary supporting members

The still water and wave loads are to be calculated for the most severe loading conditions as given in the loading manual, with a view to maximising the stresses in the longitudinal structure and primary supporting members.

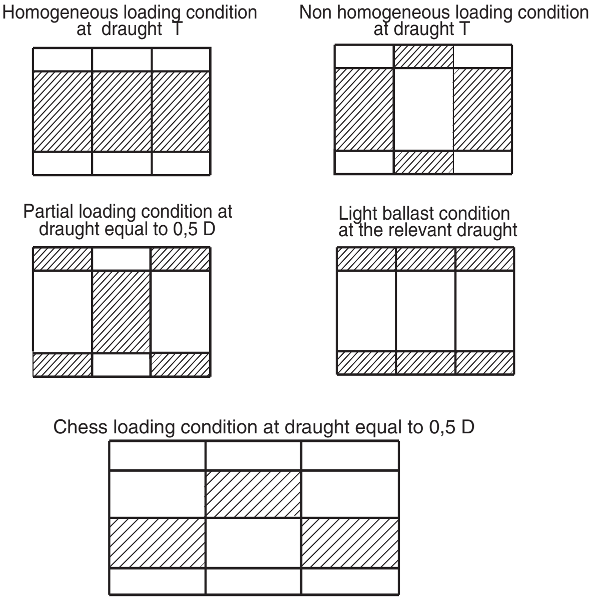
Where the loading manual is not available, the loading conditions to be considered in the analysis of primary supporting members in cargo and ballast tanks are those shown in:

- Fig 1 for ships less than 200 m in length
- Fig 2 and Fig 3 for ships equal to or greater than 200 m in length.

Table 1 : Minimum net thickness of the strength deck and bulkhead plating

Plating	Minimum net thickness, in mm	
Strength deck	$(5,5 + 0,02\, L)\, k^{1/2}$ $(8 + 0,0085\, L)\, k^{1/2}$	for $L < 200$ for $L \geq 200$
Tank bulkhead	$L^{1/3} k^{1/6} + 4,5\, s$ $1,5\, k^{1/2} + 8,2 + s$	for $L < 275$ for $L \geq 275$
Watertight bulkhead	$0,85\, L^{1/3} k^{1/6} + 4,5\, s$ $1,5\, k^{1/2} + 7,5 + s$	for $L < 275$ for $L \geq 275$
Wash bulkhead	$0,8 + 0,013\, L\, k^{1/2} + 4,5\, s$ $3,0\, k^{1/2} + 4,5 + s$	for $L < 275$ for $L \geq 275$
Note 1: s : Length, in m, of the shorter side of the plate panel.		

Figure 1 : Loading conditions for ships less than 200 m in length



4.3.3 Strength check of floors of cargo tank structure with hopper tank analysed through a three dimensional beam model

Where the cargo tank structure with hopper tank is analysed through a three dimensional beam model, to be carried out according to Pt B, Ch 7, App 1, the net shear sectional area of floors within 0,1 ℓ from the floor ends (see Fig 4 for the definition of ℓ) is to be not less than the value obtained, in cm^2, from the following formula:

$$A_{Sh} = 2\frac{Q}{\gamma_R \gamma_m R_y}$$

where:

Q : Shear force, in kN, in the floors at the ends of ℓ, obtained from the structural analysis

γ_R : Resistance partial safety factor:

$\gamma_R = 1,2$

γ_m : Material partial safety factor:

$\gamma_m = 1,02$

Figure 2 : Loading conditions for ships equal to or greater than 200 m in length *(1/7/2002)*

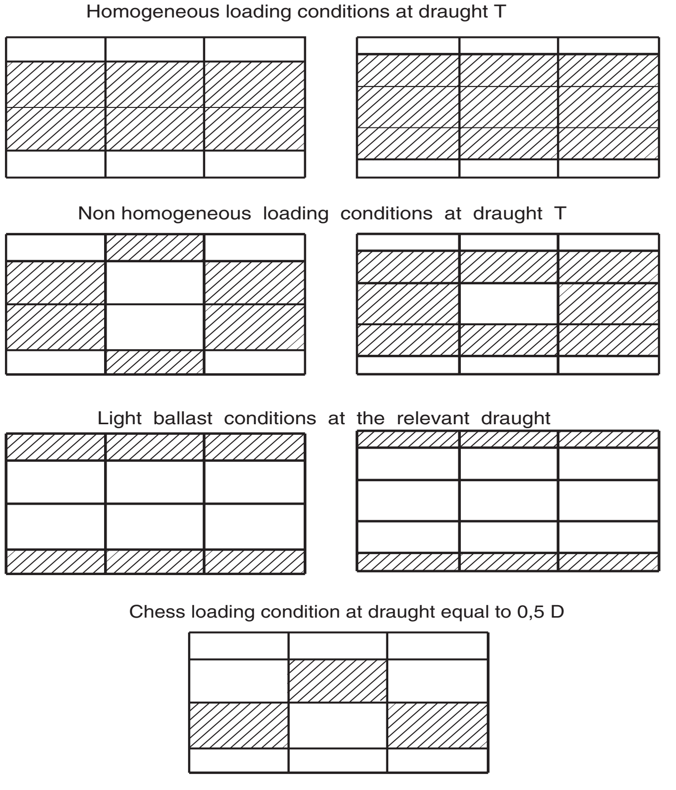
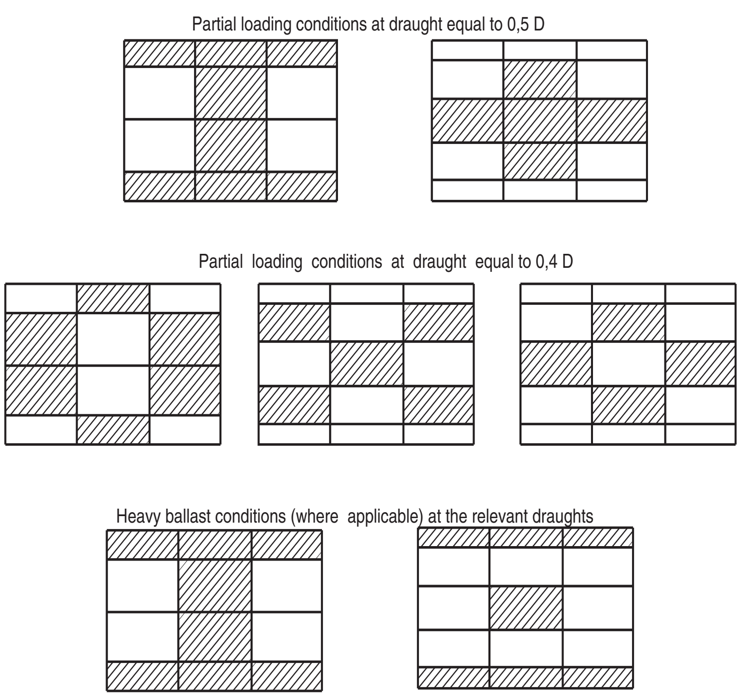


Figure 3 : Loading conditions for ships equal to or greater than 200 m in length



4.3.4 Strength checks of cross-ties analysed through a three dimensional beam model

a) Cross-ties analysed through three dimensional beam model analyses according to Pt B, Ch 7, Sec 3 are to be considered, in the most general case, as being subjected to axial forces and bending moments around the neutral axis perpendicular to the cross-tie web. This axis is identified as the y axis, while the x axis is that in the web plane (see Figures in Tab 2).

The axial force may be either tensile or compression. Depending on this, two types of checks are to be carried out, according to b) or c), respectively.

b) Strength check of cross-ties subjected to axial tensile forces and bending moments.

The net scantlings of cross-ties are to comply with the following formula:

$$10\frac{F_T}{A_{ct}} + 10^3\frac{M}{w_{yy}} \le \frac{R_y}{\gamma_R \gamma_m}$$

where:

- F_T : Axial tensile force, in kN, in the cross-ties, obtained from the structural analysis
- A_{ct} : Net sectional area, in cm², of the cross-tie
- M : Max ($|M_1|$, $|M_2|$)
- M_1, M_2 : Algebraic bending moments, in kN.m, around the y axis at the ends of the cross-tie, obtained from the structural analysis
- w_{yy} : Net section modulus, in cm³, of the cross-tie about the y axis
- γ_R : Resistance partial safety factor: $\gamma_R = 1,02$
- γ_m : Material partial safety factor: $\gamma_m = 1,02$

c) Strength check of cross-ties subjected to axial compressive forces and bending moments.

The net scantlings of cross-ties are to comply with the following formulae:

$$10F_C\left(\frac{1}{A_{ct}} + \frac{\Phi e}{w_{xx}}\right) \le \frac{R_y}{\gamma_R \gamma_m}$$

$$10\frac{F_C}{A_{ct}} + 10^3\frac{M_{max}}{w_{yy}} \le \frac{R_y}{\gamma_R \gamma_m}$$

where:

- F_C : Axial compressive force, in kN, in the cross-ties, obtained from the structural analysis
- A_{ct} : Net cross-sectional area, in cm², of the cross-tie

$$\Phi = \frac{1}{1 - \frac{F_C}{F_{EX}}}$$

- F_{EX} : Euler load, in kN, for buckling around the x axis:

$$F_{EX} = \frac{\pi^2 E I_{xx}}{10^5 \ell^2}$$

- I_{xx} : Net moment of inertia, in cm⁴, of the cross-tie about the x axis
- ℓ : Span, in m, of the cross-tie
- e : Distance, in cm, from the centre of gravity to the web of the cross-tie, specified in Tab 2 for various types of profiles
- w_{ww} : Net section modulus, in cm³, of the cross-tie about the x axis
- M_{max} : Max ($|M_0|$, $|M_1|$, $|M_2|$)

$$M_0 = \frac{\sqrt{1+t^2}(M_1 + M_2)}{2\cos(u)}$$

$$t = \frac{1}{\tan(u)}\left(\frac{M_2 - M_1}{M_2 + M_1}\right)$$

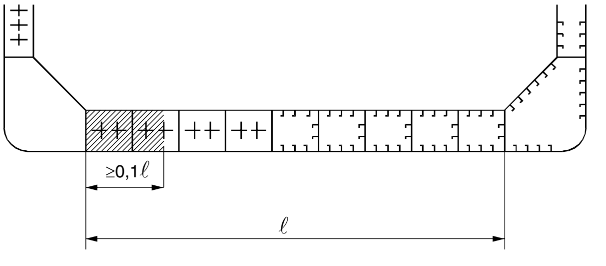
$$u = \frac{\pi}{2}\sqrt{\frac{F_C}{F_{EY}}}$$

- F_{EY} : Euler load, in kN, for buckling around the y axis:

$$F_{EY} = \frac{\pi^2 E I_{yy}}{10^5 \ell^2}$$

- I_{yy} : Net moment of inertia, in cm⁴, of the cross-tie about the y axis
- M_1, M_2 : Algebraic bending moments, in kN.m, around the y axis at the ends of the cross-tie, obtained from the structural analysis
- w_{yy} : Net section modulus, in cm³, of the cross-tie about the y axis
- γ_R : Resistance partial safety factor: $\gamma_R = 1,02$
- γ_m : Material partial safety factor: $\gamma_m = 1,02$

Figure 4 : End area of floors



4.3.5 Strength checks of cross-ties analysed through a three dimensional finite element model

a) In addition to the requirements in Pt B, Ch 7, Sec 3, [4] and Pt B, Ch 7, Sec 3, [6], the net scantlings of cross-ties subjected to compression axial stresses are to comply with the following formula:

$$|\sigma| \le \frac{\sigma_C}{\gamma_R \gamma_m}$$

where:

- σ : Compressive stress, in N/mm², obtained from a three dimensional finite element analysis, based on fine mesh modelling, according to Pt B, Ch 7, Sec 3 and Pt B, Ch 7, App 1
- σ_c : Critical stress, in N/mm², defined in b)

γ_R : Resistance partial safety factor:
$\gamma_R = 1,02$

γ_m : Material partial safety factor:
$\gamma_m = 1,02$

b) The critical buckling stress of cross-ties is to be obtained, in N/mm², from the following formulae:

$$\sigma_c = \sigma_E \quad \text{for} \quad \sigma_E \le \frac{R_y}{2}$$

$$\sigma_c = R_y\left(1 - \frac{R_y}{4\sigma_E}\right) \quad \text{for} \quad \sigma_E > \frac{R_y}{2}$$

where:

$\sigma_E = \min(\sigma_{E1}, \sigma_{E2})$,

σ_{E1} : Euler flexural buckling stress, to be obtained, in N/mm², from the following formula:

$$\sigma_{E1} = \frac{\pi^2 E I}{10^4 A_{ct} \ell^2}$$

I : Min (I_{xx}, I_{yy})

I_{xx} : Net moment of inertia, in cm⁴, of the cross-tie about the x axis defined in [4.3.4] a)

I_{yy} : Net moment of inertia, in cm⁴, of the cross-tie about the y axis defined in [4.3.4] a)

A_{ct} : Net cross-sectional area, in cm², of the cross-tie

ℓ : Span, in m, of the cross-tie

σ_{E2} : Euler torsional buckling stress, to be obtained, in N/mm², from the following formula:

$$\sigma_{E2} = \frac{\pi^2 E I_w}{10^4 I_o \ell^2} + 0,41 E \frac{J}{I_o}$$

I_w : Net sectorial moment of inertia, in cm⁴, of the cross-tie, specified in Tab 2 for various types of profiles

I_o : Net polar moment of inertia, in cm⁴, of the cross-tie

$$I_o = I_{xx} + I_{yy} + A_{ct}(y_o + e)^2$$

y_o : Distance, in cm, from the centre of torsion to the web of the cross-tie, specified in Tab 2 for various types of profiles

e : Distance, in cm, from the centre of gravity to the web of the cross-tie, specified in Tab 2 for various types of profiles,

J : St. Venant's net moment of inertia, in cm⁴, of the cross-tie, specified in Tab 2 for various types of profiles.

4.4 Strength check with respect to stresses due to the temperature gradient

4.4.1 *(1/7/2018)*

Direct calculations of stresses induced in the hull structures by the temperature gradient are to be performed for ships intended to carry cargoes at temperatures exceeding 90°C. In these calculations, the water temperature is to be assumed equal to 0°C.

The calculations are to be submitted to the Society for review.

4.4.2 The stresses induced in the hull structures by the temperature gradient are to comply with the checking criteria in Pt B, Ch 7, Sec 3, [4.3].

5 Other structures

5.1 Machinery space

5.1.1 Extension of the hull structures within the machinery space

Longitudinal bulkheads carried through cofferdams are to continue within the machinery space and are to be used preferably as longitudinal bulkheads for liquid cargo tanks. In any case, such extension is to be compatible with the shape of the structures of the double bottom, deck and platforms of the machinery space.

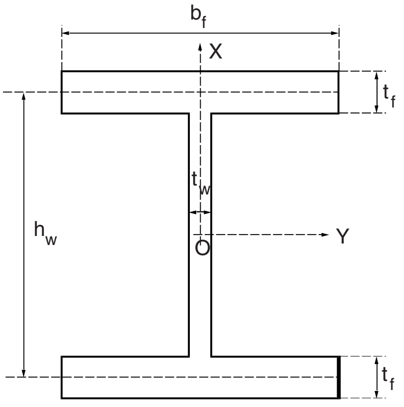
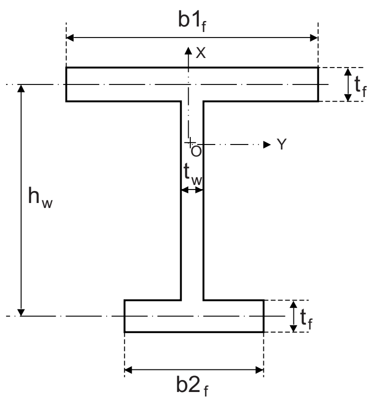
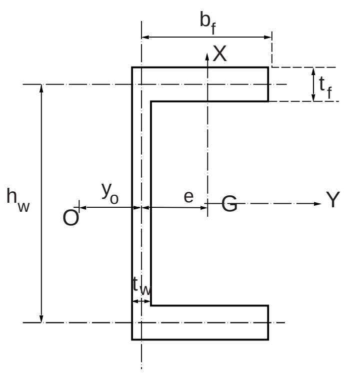
5.2 Opening arrangement

5.2.1 Tanks covers

Covers fitted on all cargo tank openings are to be of sturdy construction, and to ensure tightness for hydrocarbon and water.

Aluminium is not permitted for the construction of tank covers. The use of reinforced fibreglass covers is to be specially examined by the Society.

Table 2 : Calculation of cross-tie geometric properties

Cross-tie profile	e	y_0	J	I_w
T symmetrical 	0	0	$\frac{1}{3}(2b_f t_f^3 + h_w t_w^3)$	$\frac{t_f h_w^2 b_f^3}{24}$
T non-symmetrical 	0	0	$\frac{1}{3}\lvert(b_{1f} + b_{2f})t_f^3 + h_w t_w^3\rvert$	$\frac{t_f h_w^2 b_{1f}^3 b_{2f}^3}{12(b_{1f}^3 + b_{2f})}$
Non-symmetrical 	$\frac{b^2 t_f}{h t_w + 2 b t_f}$	$\frac{3 b_f^2 t_f}{6 b_f t_f + h_w t_w}$	$\frac{1}{3}(2b_f t_f^3 + h_w t_w^3)$	$\frac{t_f b_f^3 h^2}{12}\frac{3 b_f t_f + 2 h_w t_w}{6 b_f t_f + h_w t_w}$

6 Hull outfitting

6.1 Equipment

6.1.1 Emergency towing arrangements

The specific requirements in Pt B, Ch 10, Sec 4, [4] for ships with the service notation **oil tanker ESP** or **FLS tanker** and of 20000 t deadweight and above are to be complied with.

7 Protection of hull metallic structures

7.1 Protection of sea water ballast tanks

7.1.1 *All dedicated seawater ballast tanks are to have an efficient corrosion prevention system, such as hard protective coatings or equivalent.*

The coatings are preferably to be of a light colour, i.e. a colour easily distinguishable from rust which facilitates inspection.

Where appropriate, sacrificial anodes may also be used.

7.2 Protection by aluminium coatings

7.2.1 *(1/1/2014)*

The use of aluminium coatings containing more than 10% aluminium by weight in the dry film is prohibited in cargo tanks, the cargo tank deck area, pump rooms, cofferdams or any other area where cargo vapour may accumulate.

8 Construction and testing

8.1 Welding and weld connections

8.1.1 The welding factors for some hull structural connections are specified in Tab 3. These welding factors are to be used, in lieu of the corresponding factors specified in Pt B, Ch 12, Sec 1, Tab 2, to calculate the throat thickness of fillet weld T connections according to Pt B, Ch 12, Sec 1, [2.3]. For the connections of Tab 3, continuous fillet welding is to be adopted.

8.2 Special structural details

8.2.1 The specific requirements in Pt B, Ch 12, Sec 2, [2.3] for ships with the service notation **oil tanker ESP** are to be complied with.

Table 3 : Welding factor w_F

Hull area	Connection		Welding factor w_F
	of	to	
Double bottom in way of cargo tanks	girders	bottom and inner bottom plating	0,35
		floors (interrupted girders)	0,35
	floors	bottom and inner bottom plating	0,35
		inner bottom in way of bulkheads or their lower stools	0,45
		girders (interrupted floors)	0,35
Bulkheads **(1)**	ordinary stiffeners	bulkhead plating	0,35

(1) Not required to be applied to ships with the additional service feature **flashpoint > 60°C**.

SECTION 4 MACHINERY AND CARGO SYSTEMS FOR OIL TANKER ESP, OIL TANKER ESP CSR, FLS TANKER

1 General

1.1 Application

1.1.1 *(1/1/2012)*

The requirements of this Section apply to ships having the service notations:

- **oil tanker ESP**
- **oil tanker ESP CSR**
- **FLS tanker**

intended to carry products having any flashpoint.

The requirements in [2.1.3], [2.3.1], [2.3.5], [2.3.6], [2.3.7], [2.4.3], [3.4.6], [4.6.1] c) and d), [4.6.3] b), [4.6.4], [5] and [6.3.2], derived from MARPOL Annex I regulations, apply only to ships having the service notation **oil tanker ESP** or **oil tanker ESP CSR** (named oil tankers in this Section).

The requirements in [8.2] apply to ships having the service notation FLS tanker intended to carry substances of pollution category Z.

Some departures from these requirements may be accepted for ships of less than 500 gross tonnage as indicated in Tab 1.

1.2 Documents to be submitted

1.2.1 *(1/1/2012)*

The documents listed in Tab 2 are to be submitted for approval in four copies.

2 Piping systems other than cargo piping system

2.1 General

2.1.1 Materials *(1/1/2012)*

a) Materials are to comply with the provisions of Pt C, Ch 1, Sec 10.

b) Spheroidal graphite cast iron may be accepted for bilge and ballast piping.

2.1.2 Independence of piping systems *(1/1/2012)*

a) Bilge, ballast and scupper systems serving spaces located within the cargo area:

- are to be independent from any piping system serving spaces located outside the cargo area
- are not to lead outside the cargo area.

b) Fuel oil systems are to:

- be independent from the cargo piping system
- have no connections with pipelines serving cargo or slop tanks.

2.1.3 Passage through cargo tanks and slop tanks *(1/1/2012)*

a) Unless otherwise specified, bilge, ballast and fuel oil systems serving spaces located outside the cargo area are not to pass through cargo tanks or slop tanks. They may pass through ballast tanks or void spaces located within the cargo area.

b) Where expressly permitted, ballast pipes passing through cargo tanks are to fulfil the following provisions:

- they are to have welded or heavy flanged joints the number of which is kept to a minimum
- they are to be of extra-reinforced wall thickness as per Pt C, Ch 1, Sec 10, Tab 5
- they are to be adequately supported and protected against mechanical damage.

2.1.4 Pumps *(1/1/2012)*

One or more driven pumps are to be fitted, in a suitable space forward of cargo tanks, for bilge, ballast and, where relevant, fuel oil services.

Note 1: On ships of less than 500 gross tonnage, such pumps may be omitted provided that the above services are ensured by means of equivalent arrangements, subject to the approval of the Society.

Table 1 *(1/1/2012)*

Subject	Reference to this Section	Feature of the ship to which departures apply	Departures
Driven pumps for bilge, ballast, etc.	[2.1.4]	< 500 GRT	equivalent arrangements accepted
Drainage of pump rooms	[2.2.3]	< 500 GRT	hand pumps permitted
Drainage of cofferdams	[2.2.5]	< 500 GRT	hand pumps permitted

Table 2 : Documents to be submitted *(1/1/2012)*

No.	Description of the document **(1)**
1	General layout of cargo pump room with details of: • bulkhead penetrations • gas detection system • other alarms and safety arrangements
2	Diagram of cargo piping system
3	Diagram of the cargo tank venting system with: • indication of the outlet position • details of the pressure/vacuum valves and flame arrestors • details of the draining arrangements, if any
4	Diagram of the cargo tank level gauging system with overfill safety arrangements
5	Diagram of the cargo tank cleaning system
6	Diagram of the bilge and ballast systems serving the spaces located in the cargo area
7	Diagram of the cargo heating systems
8	Diagram of inert gas system with details of the inert gas plant
9	Diagram of gas measurement system for double hull and double bottom spaces
(1) Diagrams are also to include, where applicable, the (local and remote) control and monitoring systems and automation systems.	

2.2 Bilge system

2.2.1 Bilge pumps *(1/1/2012)*

a) At least one bilge pump is to be provided for draining the spaces located within the cargo area. Cargo pumps or stripping pumps may be used for this purpose.

b) Bilge pumps serving spaces located within the cargo area are to be located in the cargo pump room or in another suitable space within the cargo area.

2.2.2 Draining of spaces located outside the cargo area *(1/1/2012)*

For bilge draining of spaces located outside the cargo area, refer to Pt C, Ch 1, Sec 10, [6].

2.2.3 Draining of pump rooms *(1/1/2012)*

a) Arrangements are to be provided to drain the pump rooms by means of power pumps or bilge ejectors.

Note 1: On tankers of less than 500 gross tonnage, the pump rooms may be drained by means of hand pumps with a suction diameter of not less than 50 mm.

b) Cargo pumps or stripping pumps may be used for draining cargo pump rooms provided that:

- a screw-down non-return valve is fitted on the bilge suctions, and
- a remote control valve is fitted between the pump suction and the bilge distribution box.

c) Bilge pipe internal diameter is not to be less than 50 mm.

d) The bilge system of cargo pump rooms is to be capable of being controlled from outside.

e) High liquid level in the bilges is to activate an audible and visual alarm in the cargo control room and on the navigation bridge.

2.2.4 Draining of tunnels and pump rooms other than cargo pump rooms *(1/1/2012)*

Arrangements are to be provided to drain tunnels and pump rooms other than cargo pump rooms. Cargo pumps may be used for this service under the provisions of [2.2.3], item b).

2.2.5 Draining of cofferdams located at the fore and aft ends of the cargo spaces *(1/1/2012)*

a) When they are not intended to be filled with water ballast, cofferdams located at the fore and aft ends of the cargo spaces are to be fitted with drainage arrangements.

b) Aft cofferdams adjacent to the cargo pump room may be drained by a cargo pump in accordance with the provisions of [2.2.3], items b) and c), or by bilge ejectors.

c) Cofferdams located at the fore end of the cargo spaces may be drained by the bilge or ballast pumps required in [2.1.4], or by bilge ejectors.

d) Drainage of the after cofferdam from the engine room bilge system is not permitted.

Note 1: On tankers of less than 500 gross tonnage, cofferdams may be drained by means of hand pumps with a suction diameter of not less than 50 mm.

2.2.6 Drainage of other cofferdams and void spaces located within the cargo area *(1/1/2012)*

Other cofferdams and void spaces located within the cargo area and not intended to be filled with water ballast are to be fitted with suitable means of drainage.

2.3 Ballast system

2.3.1 General *(1/1/2012)*

a) Every crude oil tanker of 20 000 tonnes deadweight and above and every product carrier of 30 000 tonnes deadweight and above is to be provided with segregated ballast tanks.

b) Except where expressly permitted, ballast systems serving segregated ballast tanks are to be completely separated from the cargo oil and fuel oil systems.

c) In oil tankers of 150 gross tonnage and above, no ballast water is normally to be carried in any fuel oil tank; see Pt C, Ch 1, Sec 10, [7.1.3].

d) In:

- crude oil tankers of 20 000 tonnes deadweight and above
- product carriers of 30 000 tonnes deadweight and above,

no ballast water is to be carried in cargo tanks, except in exceptional cases.

2.3.2 Ballast pumps *(1/1/2012)*

a) Ballast pumps are to be located in the cargo pump room, or a similar space within the cargo area not containing any source of ignition.

b) Where installed in the cargo pump room, ballast pumps are to comply with the applicable provisions of [3.2.3] and [3.2.4].

2.3.3 Pumping arrangements for ballast tanks within the cargo area *(1/1/2012)*

a) Ballast systems serving segregated ballast in the cargo area are to be entirely located within the cargo area and are not to be connected to other piping systems.

b) Segragated ballast tanks located within the cargo area are to be served by two different means. At least one of these means is to be a pump or an eductor used exclusively for dealing with ballast.

2.3.4 Pumping arrangement for cofferdams located at the fore and aft ends of the cargo spaces *(1/1/2012)*

Where they are intended to be filled with water ballast, the cofferdams located at the fore and aft ends of the cargo spaces may be emptied by a ballast pump located inside the machinery compartment or the forward space mentioned in [2.1.4], whichever is the case, provided that:

- the suction is directly connected to the pump and not to a piping system serving machinery spaces
- the delivery is directly connected to the ship side.

2.3.5 Emergency discharge of segregated ballast *(1/1/2012)*

Provisions may be made for emergency discharge of the segregated ballast by means of a connection to a cargo pump through a detachable spool piece provided that:

- non-return valves are fitted on the segregated ballast connections to prevent the passage of oil to the ballast tank, and
- shut-off valves are fitted to shut off the cargo and ballast lines before the spool piece is removed.

The detachable spool piece is to be placed in a conspicuous position in the pump room and a permanent warning notice restricting its use is to be displayed in a conspicuous position adjacent to it.

2.3.6 Carriage of ballast water in cargo tanks *(1/1/2012)*

a) Provisions are to be made for filling cargo tanks with sea water, where permitted. Such ballast water is to be processed and discharged using the equipment referred to in [5].

b) The sea water inlets and overboard discharges serving cargo tanks for the purpose of a) are not to have any connection with the ballast system of segregated ballast tanks.

c) Cargo pumps may be used for pumping ballast water to or from the cargo tanks, provided two shut-off valves are fitted to isolate the cargo piping system from the sea inlets and overboard discharges. See also [5.3.4].

d) Ballast pumps serving segregated ballast tanks may be used for filling the cargo tanks with sea water provided that the connection is made on the top of the tanks and consists of a detachable spool piece and a screw-down non-return valve to avoid siphon effects.

2.3.7 Ballast pipes passing through tanks *(1/1/2012)*

a) In oil tankers of 600 tonnes deadweight and above, ballast piping is not to pass through cargo tanks except in the case of short lengths of piping complying with [2.1.3], item b).

b) Sliding type couplings are not to be used for expansion purposes where ballast lines pass through cargo tanks. Expansion bends only are permitted.

2.3.8 Fore peak ballast system on oil tankers *(1/1/2019)*

The fore peak tank can be ballasted with the system serving ballast tanks within the cargo area, provided:

a) the fore peak tank is considered a hazardous area (see Note 1)

b) the vent pipe openings are located on open deck at an appropriate distance from sources of ignition. In this respect, the distance is to be of at least 3 m, as requested for openings into cofferdams or other Zone 1 spaces (1.5 m hazardous area Zone 1 + 1.5 m hazardous area Zone 2) according to IEC 60092-502: Electrical installations in ships - Tankers - Special features;

c) c)means are provided, on the open deck, to allow measurement of flammable gas concentrations within the fore peak tank by a suitable portable instrument;

d) the sounding arrangements to the fore peak tank are direct from the open deck.

Note 1: The hazardous area classification is to be defined in accordance with IEC 60092-502: Electrical installations in ships - Tankers - Special features.

2.3.9 Integrated cargo and ballast system *(1/1/2012)*

The requirements for integrated cargo and ballast systems are given in [3.5].

2.4 Air and sounding pipes of spaces other than cargo tanks

2.4.1 General *(1/1/2012)*

The air and sounding pipes fitted to the following spaces:

- cofferdams located at the fore and aft ends of the cargo spaces
- tanks and cofferdams located within the cargo area and not intended for cargo

are to be led to the open.

2.4.2 Air pipes *(1/1/2012)*

The air pipes referred to in [2.4.1] are to be arranged as per Pt C, Ch 1, Sec 10, [9] and are to be fitted with easily removable flame screens at their outlets.

2.4.3 Passage through cargo tanks *(1/1/2012)*

In oil tankers of 600 tonnes deadweight and above, the air and sounding pipes referred to in [2.4.1] are not to pass through cargo tanks except in the following cases:

- short lengths of piping serving ballast tanks
- lines serving double bottom tanks located within the cargo area, except in the case of oil tankers of 5000 tonnes deadweight and above

where the provisions of [2.1.3], item b) are complied with.

2.5 Scupper pipes

2.5.1 *(1/1/2012)*

Scupper pipes are not to pass through cargo tanks except, where this is impracticable, in the case of short lengths of piping complying with the following provisions:

- they are of steel
- they have only welded or heavy flanged joints the number of which is kept to a minimum
- they are of substantial wall thickness as per Pt C, Ch 1, Sec 10, Tab 22, column 1.

2.6 Heating systems intended for cargo

2.6.1 General *(1/1/2012)*

a) Heating systems intended for cargo are to comply with the relevant requirements of Pt C, Ch 1, Sec 10.

b) The steam and heating media temperature within the cargo area is not to exceed 220° C.

c) Blind flanges or similar devices are to be provided on the heating circuits fitted to tanks carrying cargoes which are not to be heated.

d) Heating systems are to be so designed that the pressure maintained in the heating circuits is higher than that exerted by the cargo oil. This need not be applied to heating circuits which are not in service provided they are drained and blanked-off.

e) Isolating valves are to be provided at the inlet and outlet connections of the tank heating circuits. Arrangements are to be made to allow manual adjustement of the flow.

f) Heating pipes and coils inside tanks are to be built of a material suitable for the heated fluid. They are to have welded connections only.

2.6.2 Steam heating *(1/1/2012)*

To reduce the risk of liquid or gaseous cargo returns inside the engine or boiler rooms, steam heating systems of cargo tanks are to satisfy either of the following provisions:

- they are to be independent of other ship services, except cargo heating or cooling systems, and are not to enter machinery spaces, or
- they are to be provided with an observation tank on the water return system located within the cargo area. However, this tank may be placed inside the engine room in a well-ventilated position remote from boilers and other sources of ignition. Its air pipe is to be led to the open and fitted with a flame arrester.

2.6.3 Hot water heating *(1/1/2012)*

Hot water systems serving cargo tanks are to be independent of other systems. They are not to enter machinery spaces unless the expansion tank is fitted with:

- means for detection of flammable vapours
- a vent pipe led to the open and provided with a flame arrester.

2.6.4 Thermal oil heating

Thermal oil heating systems serving cargo tanks are to be arranged by means of a separate secondary system, located completely within the cargo area. However, a single circuit system may be accepted provided that:

- the system is so arranged as to ensure a positive pressure in the coil of at least 3 m water column above the static head of the cargo when the circulating pump is not in operation
- means are provided in the expansion tank for detection of flammable cargo vapours. Portable equipment may be accepted.
- valves for the individual heating coils are provided with a locking arrangement to ensure that the coils are under static pressure at all times.

3 Cargo pumping systems

3.1 General

3.1.1 *(1/1/2012)*

A complete system of pumps and piping is to be fitted for handling the cargo.

3.1.2 *(1/1/2012)*

Except where expressly permitted, and namely for the bow and stern cargo loading and unloading stations, this system is not to extend outside the cargo area and is to be independent of any other piping system on board.

3.2 Cargo pumping system

3.2.1 Number and location of cargo pumps *(1/1/2012)*

a) Each cargo tank is to be served by at least two separate fixed means of discharging and stripping. However, for tanks fitted with an individual submerged pump, the second means may be portable.

b) Cargo pumps are to be located:

- in a dedicated pump room, or
- on deck, or
- when designed for this purpose, within the cargo tanks.

3.2.2 Use of cargo pumps *(1/1/2012)*

a) Except where expressly permitted in [2.2] and [2.3], cargo pumps are to be used exclusively for handling the liquid cargo and are not to have any connections to compartments other than cargo tanks.

b) Subject to their performance, cargo pumps may be used for tank stripping.

c) Cargo pumps may be used, where necessary, for the washing of cargo tanks.

3.2.3 Cargo pumps drive *(1/1/2012)*

a) Prime movers of cargo pumps are not to be located in the cargo area, except in the following cases:

- steam driven machine supplied with steam having a temperature not exceeding 220 °C
- hydraulic motors
- electric motors of certified type.

b) Pumps with a submerged electric motor are not permitted in cargo tanks.

c) Where cargo pumps are driven by a machine which is located outside the cargo pump room, the following arrangements are to be made:

1) drive shafts are to be fitted with flexible couplings or other means suitable to compensate for any misalignment
2) the shaft bulkhead or deck penetration is to be fitted with a gas-tight gland of a type approved by the Society. The gland is to be efficiently lubricated from outside the pump room and so designed as to prevent overheating. The seal parts of the gland are to be of material that cannot initiate sparks.
3) Temperature sensing devices are to be fitted for bulkhead shaft gland bearings; see [3.2.5].

Note 1: The provisions of this requirement also apply to stripping pumps and ballast pumps.

3.2.4 Design of cargo pumps *(1/1/2012)*

a) Materials of cargo pumps are to be suitable for the products carried.

b) The delivery side of cargo pumps is to be fitted with relief valves discharging back to the suction side of the pumps (bypass) in closed circuit. Such relief valves may be omitted in the case of centrifugal pumps with a maximum delivery pressure not exceeding the design pressure of the piping, with the delivery valve closed.

c) Pump casings are to be fitted with temperature sensing devices; see [3.2.5].

3.2.5 Monitoring of cargo pumps *(1/1/2012)*

Cargo pumps are to be monitored as required in Tab 3.

3.2.6 Control of cargo pumps *(1/1/2012)*

Cargo pumps are to be capable of being stopped from:

- a position outside the pump room, and
- a position next to the pumps.

Table 3 : Monitoring of cargo pumps *(1/1/2012)*

Equipment, parameter	Alarm **(1)**	Indication **(2)**	Comments
pump, discharge pressure		L	• on the pump **(3)**, or • next to the unloading control station
pump casing, temperature	H		visual and audible, in cargo control room or pump control station
bulkhead shaft gland bearing, temperature	H		visual and audible, in cargo control room or pump control station
(1) H = high **(2)** L = low **(3)** and next to the driving machine if located in a separate compartment			

3.3 Cargo piping design

3.3.1 General *(1/1/2012)*

a) Unless otherwise specified, cargo piping is to be designed and constructed according to the requirements of Pt C, Ch 1, Sec 10 applicable to piping systems of:

- class III, in the case of ships having the service notation **oil tanker**
- class II, in the case of ships having the service notation **FLS tanker**, with the exception of cargo pipes and accessories having an open end or situated inside cargo tanks, for which class III may be accepted.

b) For tests, refer to [6].

3.3.2 Materials *(1/1/2012)*

a) Cargo piping is, in general, to be made of steel or cast iron.

b) Valves, couplings and other end fittings of cargo pipe lines for connection to hoses are to be of steel or other suitable ductile material.

c) Spheroidal graphite cast iron may be used for cargo oil piping.

d) Grey cast iron may be accepted for cargo oil lines:

- within cargo tanks, and
- on the weather deck for pressure up to 1,6 Mpa.

It is not to be used for manifolds and their valves of fittings connected to cargo handling hoses.

e) Plastic pipes may be used in the conditions specified in Pt C, Ch 1, App 3. Arrangements are to be made to avoid the generation of static electricity.

3.3.3 Connection of cargo pipe lengths *(1/1/2012)*

Cargo pipe lengths may be connected either by means of welded joints or, unless otherwise specified, by means of flange connections.

3.3.4 Expansion joints *(1/1/2012)*

a) Where necessary, cargo piping is to be fitted with expansion joints or bends.

b) Expansion joints including bellows are to be of a type approved by the Society.

c) Expansion joints made of non-metallic material may be accepted only inside tanks and provided they are:

- of an approved type
- designed to withstand the maximum internal and external pressure
- electrically conductive.

d) In **oil tanker**, sliding type couplings are not to be used for expansion purposes where lines for cargo oil pass through tanks for segregated ballast.

e) In **FLS tanker**, slip joints are not to be used for cargo piping systems with the exception of pipe sections inside cargo tanks served by such sections.

3.3.5 Valves with remote control *(1/1/2012)*

a) Valves with remote control are to comply with Pt C, Ch 1, Sec 10, [2.7.3].

b) Submerged valves are to be remote controlled. In the case of a hydraulic remote control system, control boxes are to be provided outside the tank, in order to permit the emergency control of valves.

c) Valve actuators located inside cargo tanks are not to be operated by means of compressed air.

3.3.6 Cargo hoses *(1/1/2012)*

a) Cargo hoses are to be of a type approved by the Society for the intended conditions of use.

b) Hoses subject to tank pressure or pump discharge pressure are to be designed for a bursting pressure not less than 4 times the maximum pressure under cargo transfer conditions.

c) The ohmic electrical resistance of cargo hoses is not to exceed $10^6 \Omega$.

3.4 Cargo piping arrangement and installation

3.4.1 Cargo pipes passing through tanks or compartments *(1/1/2012)*

a) Cargo piping is not to pass through tanks or compartments located outside the cargo area.

b) Cargo piping and similar piping to cargo tanks is not to pass through ballast tanks except in the case of short lengths of piping complying with [2.1.3], item b).

c) Cargo piping may pass through vertical fuel oil tanks adjacent to cargo tanks on condition that the provisions of [2.1.3], item b) are complied with.

d) Piping through cargo tanks, see also Ch 7, Sec 2, [3.1.4].

3.4.2 Cargo piping passing through bulkheads *(1/1/2012)*

Cargo piping passing through bulkheads is to be so arranged as to preclude excessive stresses at the bulkhead. Bolted flanges are not to be used in the bulkhead.

3.4.3 Valves *(1/1/2012)*

a) Stop valves are to be provided to isolate each tank.

b) A stop valve is to be fitted at each end of the cargo manifold.

c) When a cargo pump in the cargo pump room serves more than one cargo tank, a stop valve is to be fitted in the cargo pump room on the line leading to each tank.

d) Main cargo oil valves located in the cargo pump room below the floor gratings are to be remote controlled from a position above the floor.

3.4.4 Prevention of the generation of static electricity *(1/1/2014)*

To avoid the hazard of an incendive discharge due to the build-up of static electricity resulting from the flow of the liquid/gases/vapours, the following requirements are to be complied with:

- the loading pipes are to be led as low as practicable in the tank
- the resistance between any point on the surface of the cargo and slop tanks, piping systems and equipment, and the hull of the ship is not to be greater than $10^6\ \Omega$.

Bonding straps are required for cargo and slop tanks, piping systems and equipment which are not permanently connected to the hull of the ship, for example:

a) independent cargo tanks

b) cargo tank piping systems which are electrically separated from the hull of the ship

c) pipe connections arranged for the removal of the spool pieces

d) wafer-style valves with non-conductive (e.g. PTFE) gaskets or seals.

Where bonding straps are required, they are to be:

- clearly visible so that any shortcoming can be clearly detected
- designed and sited so that they are protected against mechanical damage and are not affected by high resistivity contamination, e.g. corrosive products or paint
- easy to install and replace.

3.4.5 Bow or stern cargo loading and unloading arrangements *(1/1/2012)*

Where the ship is arranged for loading and unloading outside the cargo area, the following provisions are to be complied with:

a) the piping outside the cargo area is to be fitted with a shut-off valve at its connection with the piping system within the cargo area and separating means such as blank flanges or removable spool pieces or equivalent (see Note 1) are to be provided when the piping outside the cargo area is not in use

Note 1: Those indicated in the IMO MSC/Circ. 474 are acceptable as equivalent

b) the shore connection is to be fitted with a shut-off valve and a blank flange

c) pipe connections outside the cargo area are to be of welded type only

d) arrangements are made to allow the piping outside the cargo area to be efficiently drained and purged.

3.4.6 Draining of cargo pumps and oil lines *(1/1/2012)*

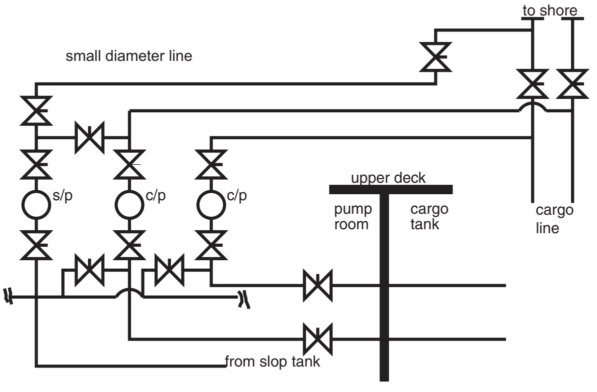
Every oil tanker required to be provided with segregated ballast tanks or fitted with a crude oil washing system is to comply with the following requirements:

a) it is to be equipped with oil piping so designed and installed that oil retention in the lines is minimised, and

b) means are to be provided to drain all cargo pumps and all oil lines at the completion of cargo discharge, where necessary by connection to a stripping device. The line and pump drainings are to be capable of being discharged both ashore and to a cargo tank or slop tank. For discharge ashore, a special small diameter line having a cross-sectional area not exceeding 10% of the main cargo discharge line is to be provided and is to be connected on the downstream side of the tanker's deck manifold valves, both port and starboard, when the cargo is being discharged; see Fig 1.

For oil tankers fitted with a crude oil washing system, refer also to App 2, [2.4.5].

Figure 1 : Connection of small diameter line to the manifold valve *(1/1/2012)*



3.4.7 Cleaning and gas-freeing *(1/1/2012)*

a) The cargo piping system is to be so designed and arranged as to permit its efficient cleaning and gas-freeing.

b) Requirements for inert gas systems are given in Part C, Chapter 4.

3.5 Integrated cargo and ballast systems design

3.5.1 Functional requirements *(1/1/2012)*

The operation of cargo and/or ballast systems may be necessary, under certain emergency circumstances or during the course of navigation, to enhance the safety of tankers.

As such, measures are to be taken to prevent cargo and ballast pumps becoming inoperative simultaneously due to a single failure in the integrated cargo and ballast system, including its control and safety systems. The same criteria apply to control systems of cargo and ballast valves.

3.5.2 Design features *(1/1/2012)*

The following design features are, inter alia, to be fitted:

a) the emergency stop circuits of the cargo and ballast systems are to be independent from the circuits for the control systems. A single failure in the control system circuits or the emergency stop circuits is not to render the integrated cargo and ballast system inoperative;

b) manual emergency stops of the cargo pumps are to be arranged such that they do not cause the shutdown of the power pack making ballast pumps inoperable;

c) the control systems are to be provided with backup power supply, which may be satisfied by a duplicate power supply from the main switchboard. The failure of any power supply is to provide audible and visible alarm activation at each location where the control panel is fitted.

d) in the event of failure of the automatic or remote control systems, a secondary means of control is to be made available for the operation of the integrated cargo and ballast system. This is to be achieved by manual overriding and/or redundant arrangements within the control systems.

4 Cargo tanks and fittings

4.1 Application

4.1.1 *(1/1/2012)*

The provisions of Article [4] apply to cargo tanks and slop tanks.

4.2 Cargo tank venting

4.2.1 Principle *(1/1/2012)*

Cargo tanks are to be provided with venting systems *entirely distinct from the air pipes of the other compartments of the ship. The arrangements and position of openings in the cargo tank deck from which emission of flammable vapours can occur are to be such as to minimise the possibility of flammable vapours being admitted to enclosed spaces containing a source of ignition, or collecting in the vicinity of deck machinery and equipment which may constitute an ignition hazard.*

4.2.2 Design of venting arrangements *(1/1/2015)*

The venting arrangements are to be so designed and operated as to ensure that neither pressure nor vacuum in cargo tanks exceeds design parameters and be such as to provide for:

a) the flow of the small volumes of vapour, air or inert gas mixtures caused by thermal variations in a cargo tank in all cases through pressure/vacuum valves, and

b) the passage of large volumes of vapour, air or inert gas mixtures during cargo loading and ballasting, or during discharging,

c) a secondary means of allowing full flow relief of vapour, air or inert gas mixtures to prevent overpressure or underpressure in the event of failure of the arrangements in b). Alternatively, pressure sensors may be fitted in each tank protected by the arrangement required in b), with a monitoring system in the ship's cargo control room or the position from which cargo operations are normally carried out. Such monitoring equipment is also to provide an alarm facility which is activated by detection of overpressure or underpressure conditions within a tank.

The setting of the overpressure alarm is to be above the pressure setting of the P/V-valve and the setting of the underpressure alarm shall be below the vacuum setting of the P/V-valve. The alarm settings are to be within the design pressures of the cargo tanks. The settings are to be fixed and not arranged for blocking or adjustment in operation, except for ships that carry different types of cargo and use P/V valves with different settings, one setting for each type of cargo.

4.2.3 Combination of venting arrangements *(1/1/2015)*

a) The venting arrangements in each cargo tank may be independent or, where the cargo is homogenous or, for multiple cargoes, where the vapours are compatible and do not require isolation, they may be combined with other cargo tanks or be incorporated into the inert gas piping.

b) *Where the arrangements are combined with other cargo tanks, either stop valves or other acceptable means are to be provided to isolate each cargo tank. Where stop valves are fitted, they are to be provided with locking arrangements which are to be under the control of the responsible ship's officer. There is to be a clear visual indication of the operational status of the valves or other acceptable means. Where tanks have been isolated, it is to be ensured that relevant isolating valves are opened before cargo loading or ballasting or discharging of those tanks is commenced. Any isolation must continue to permit the flow caused by thermal variations in a cargo tank in accordance with [4.2.2] a).*

c) *If cargo loading and ballasting or discharging of a cargo tank or cargo tank group is intended, which is isolated from a common venting system, that cargo tank or cargo tank group is to be fitted with a means for overpressure or underpressure protection as required in [4.2.2] c).*

4.2.4 Arrangement of vent lines *(1/1/2012)*

The venting arrangements are to be connected to the top of each cargo tank and are to be self-draining to the cargo tanks under all normal conditions of trim and list of the ship. Where it may not be possible to provide self-draining lines, permanent arrangements are to be provided to drain the vent lines to a cargo tank.

Plugs or equivalent means are to be provided on the lines after the safety relief valves.

4.2.5 Openings for pressure release *(1/1/2012)*

Openings for pressure release required by [4.2.2] a) are to:

a) *have as great a height as is practicable above the cargo tank deck to obtain maximum dispersal of flammable vapours but in no case less than 2 m above the cargo tank deck,*

b) *be arranged at the furthest distance practicable but not less than 5 m from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery and equipment which may constitute an ignition hazard. Anchor windlass and chain locker openings constitute an ignition hazard.*

4.2.6 Pressure/vacuum valves *(1/1/2012)*

a) *One or more pressure/vacuum-breaking devices are to be provided to prevent the cargo tanks from being subject to:*

   1) *a positive pressure, in excess of the test pressure of the cargo tank, if the cargo were to be loaded at the maximum rated capacity and all other outlets were left shut; and*

   2) *a negative pressure in excess of 700 mm water gauge if cargo were to be discharged at the maximum rated capacity of the cargo pumps and the inert gas blowers were to fail.*

   Such devices are to be installed on the inert gas main unless they are installed in the venting system required by this item [4.2] or on individual cargo tanks.

b) Pressure/vacuum valves are to be set at a positive pressure not exceeding 0,021 *MPa* and at a negative pressure not exceeding 0,007 *MPa.* Higher setting values not exceeding 0,07 *MPa* may be accepted in positive pressure if the scantlings of the tanks are appropriate.

c) *Pressure/vacuum valves required by item a) of [4.2.2] may be provided with a bypass when they are located in a vent main or masthead riser. Where such an arrangement is provided, there are to be suitable indicators to show whether the bypass is open or closed.*

d) Pressure/vacuum valves are to be of a type approved by the Society in accordance with App 1.

e) Pressure/vacuum valves are to be readily accessible.

f) Pressure/vacuum valves are to be provided with a manual opening device so that valves can be locked on open position. Locking means on closed position are not permitted.

4.2.7 Vent oulets *(1/1/2012)*

Vent outlets for cargo loading, discharging and ballasting required by [4.2.2] b) are to:

a) *permit:*

   - *the free flow of vapour mixtures, or*
   - *the throttling of the discharge of the vapour mixtures to achieve a velocity of not less than 30 m/s,*

b) *be so arranged that the vapour mixture is discharged vertically upwards,*

c) *where the method is by free flow of vapour mixtures, be such that the outlet is not less than 6 m above the cargo tank deck or fore and aft gangway if situated within 4 m of the gangway and located not less than 10 m measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery which may include anchor windlass and chain locker openings, and equipment which may constitute an ignition hazard,*

d) *where the method is by high velocity discharge, be located at a height not less than 2 m above the cargo tank deck and not less than 10 m measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery which may include anchor windlass and chain locker openings, and equipment which may constitute an ignition hazard. These outlets are to be provided with high velocity devices of a type approved by the Society,*

e) *be designed on the basis of the maximum designed loading rate multiplied by a factor of at least 1,25 to take account of gas evolution, in order to prevent the pressure in any cargo tank from exceeding the design pressure. The Master is to be provided with information regarding the maximum permissible loading rate for each cargo tank and in the case of combined venting systems, for each group of cargo tanks.*

   The arrangements for the venting of vapours displaced from the cargo tanks during loading and ballasting are to comply with this item [4.2] and are to consist of either one or more mast risers, or a number of high-velocity vents. The inert gas supply main may be used for such venting.

4.2.8 High velocity valves *(1/1/2012)*

a) High velocity valves are to be readily accessible.

b) High velocity valves not required to be fitted with flame arresters (see [4.2.9]) are not to be capable of being locked on open position.

4.2.9 Prevention of the passage of flame into the tanks *(1/1/2012)*

a) *The venting system is to be provided with devices to prevent the passage of flame into the cargo tanks. The design, testing and locating of these devices are to comply with App 1.*

Ullage openings are not to be used for pressure equalisation. They are to be provided with self-closing and tightly sealing covers. Flame arresters and screens are not permitted in these openings.

b) A flame arresting device integral to the venting system may be accepted.

c) Flame screens and flame arresters are to be designed for easy overhauling and cleaning.

4.2.10 Prevention of liquid rising in the venting system *(1/1/2012)*

a) Provisions are to be made to prevent liquid rising in the venting system; refer to [4.5].

b) Cargo tanks gas venting systems are not to be used for overflow purposes.

c) Spill valves are not considered equivalent to an overflow system.

4.3 Cargo tank purging and/or gas-freeing

4.3.1 General *(1/1/2012)*

a) Arrangements are to be made for purging and/or gas-freeing of cargo tanks. The arrangements *are to be such as to minimise the hazards due to the dispersal of flammable vapours in the atmosphere and to flammable mixtures in a cargo tank. Accordingly, the provisions of [4.3.2] and [4.3.3], as applicable, are to be complied with.*

b) In the case of fans installed in safe spaces, two non-return devices are to be fitted to avoid return of cargo vapours to safe spaces when the ventilation system is shut down. These non-return devices are to operate in all normal conditions of ship trim and list.

c) Discharge outlets are to be located at least 10 m measured horizontally from the nearest air intake and openings to enclosed spaces with a source of ignition and from deck machinery equipment which may constitute an ignition hazard.

4.3.2 Ships provided with an inert gas system *(1/1/2012)*

When the ship is provided with an inert gas system, the cargo tanks are first to be purged in accordance with the provisions of Part C, Chapter 4 until the concentration of hydrocarbon vapours in the cargo tanks has been reduced to less than 2% by volume. Thereafter, gas-freeing may take place at the cargo tank deck level.

4.3.3 Ships not provided with an inert gas system *(1/1/2012)*

When the ship is not provided with an inert gas system, the operation is to be such that the flammable vapour is discharged initially:

a) through the vent outlets as specified in [4.2.7], or

b) through outlets at least 2 m above the cargo tank deck level with a vertical efflux velocity of at least 30 m/s maintained during the gas-freeing operation, or

c) through outlets at least 2 m above the cargo tank deck level with a vertical efflux velocity of at least 20 m/s and which are protected by suitable devices to prevent the passage of flame.

The above outlets are to be located not less than 10 m measured horizontally from the nearest air intakes and openings to enclosed spaces containing a source of ignition and from deck machinery, which may include anchor windlass and chain locker openings, and equipment which may constitute an ignition hazard.

When the flammable vapour concentration at the outlet has been reduced to 30% of the lower flammable limit, gas-freeing may thereafter be continued at cargo tank deck level.

4.4 Cargo tank level gauging systems

4.4.1 General *(1/1/2012)*

a) Each cargo or slop tank is to be fitted with a level gauging system indicating the liquid level along the entire height of the tank. Unless otherwise specified, the gauge may be portable or fixed with local reading.

b) Gauging devices and their remote reading systems are to be type approved.

c) Ullage openings and other gauging devices likely to release cargo vapour to the atmosphere are not to be arranged in enclosed spaces.

4.4.2 Definitions *(1/1/2012)*

a) A “restricted gauging device” means a device which penetrates the tank and which, when in use, permits a small quantity of vapour or liquid to be exposed to the atmosphere. When not in use, the device is completely closed. Examples are sounding pipes.

b) A “closed gauging device” means a device which is separated from the tank atmosphere and keeps tank contents from being released. It may:

- penetrate the tank, such as float-type systems, electric probe, magnetic probe or protected sight glass,
- not penetrate the tank, such as ultrasonic or radar devices.

c) An “indirect gauging device” means a device which determines the level of liquid, for instance by means of weighing or pipe flow meter .

4.4.3 Tankers fitted with an inert gas system *(1/1/2012)*

a) In tankers fitted with an inert gas system, the gauging devices are to be of the closed type.

b) Use of indirect gauging devices will be given special consideration.

4.4.4 Tankers not fitted with an inert gas system *(1/1/2012)*

a) In tankers not fitted with an inert gas system, the gauging devices are to be of the closed or restricted types. Ullage openings may be used only as a reserve sounding means and are to be fitted with a watertight closing appliance.

b) Where restricted gauging devices are used, provisions are to be made to:

- avoid dangerous escape of liquid or vapour under pressure when using the device
- relieve the pressure in the tank before the device is operated.

c) Where used, sounding pipes are to be fitted with a a self-closing blanking device.

4.5 Protection against tank overload

4.5.1 General *(1/1/2012)*

a) Provisions are to be made to guard against liquid rising in the venting system of cargo or slop tanks to a height which would exceed the design head of the tanks. This is to be accomplished by high level alarms or overflow control systems or other equivalent means, together with gauging devices and cargo tank filling procedures.

Note 1: For ships having the service notation **FLS tanker**, only high level alarms are permitted.

b) Sufficient ullage is to be left at the end of tank filling to permit free expansion of liquid during carriage.

c) High level alarms, overflow control systems and other means referred to in a) are to be independent of the gauging systems referred to in [4.4].

4.5.2 High level alarms *(1/1/2012)*

a) High level alarms are to be type approved.

b) High level alarms are to give an audible and visual signal at t he control station, where provided.

4.5.3 Other protection systems *(1/7/2021)*

Where the tank level gauging systems, cargo and ballast pump control systems and valve control systems are centralised in a single location, the provisions of [4.5.1] may be complied with by the fitting of a level gauge for the indication of the end of loading, in addition to that required for each tank under [4.4]. The readings of both gauges for each tank are to be as near as possible to each other and so arranged that any discrepancy between them can be easily detected.

4.6 Tank washing systems

4.6.1 General *(1/1/2012)*

a) Adequate means are to be provided for cleaning the cargo tanks.

b) For ships having the service notation FLS tanker carrying category Z substances, see [8].

c) Every crude oil tanker of 20 000 tonnes deadweight and above is to be fitted with a cargo tank cleaning system using crude oil washing and complying with App 2.

d) Crude oil washing systems fitted on oil tankers other than crude oil tankers of 20 000 tonnes deadweight or above are to comply with the provisions of App 2 related to safety.

4.6.2 Washing machines *(1/1/2012)*

a) Tank washing machines are to be of a type approved by the Society.

b) Washing machines are to be made of steel or other electricity conducting materials with a limited propensity to produce sparks on contact.

4.6.3 Washing pipes *(1/1/2012)*

a) Washing pipes are to be built, fitted, inspected and tested in accordance with the applicable requirements of Pt C, Ch 1, Sec 10, depending on the kind of washing fluid, water or crude oil.

b) Crude oil washing pipes are also to satisfy the requirements of Article [3.3].

4.6.4 Use of crude oil washing machines for water washing operations *(1/1/2012)*

Crude oil washing machines may be connected to water washing pipes, provided that isolating arrangements, such as a valve and a detachable pipe section, are fitted to isolate water pipes.

4.6.5 Installation of washing systems *(1/1/2012)*

a) Tank cleaning openings are not to be arranged in enclosed spaces.

b) The complete installation is to be permanently earthed to the hull.

5 Prevention of pollution by cargo oil

5.1 General

5.1.1 Application *(1/7/2015)*

Unless otherwise specified, the provisions of [5.2] apply only to oil tankers of 150 gross tonnage and above.

5.1.2 Provisions for oil tankers of less than 150 gross tonnage *(1/1/2012)*

The control of discharge for **oil tankers** of less than 150 gross tonnage is to be effected by the retention of oil on board with subsequent discharge of all contaminated washings to reception facilities unless adequate arrangements are made to ensure that the discharge of any effluent into the sea, where allowed, is effectively monitored to ensure that the total quantity of oil discharged into the sea does not exceed 1/30 000 of the total quantity of the particular cargo of which the residue formed a part.

5.1.3 Exemptions *(1/1/2012)*

a) The provisions of [5.2] may be waived in the following cases:
   - oil tankers engaged exclusively on voyages within 50 miles from the nearest land and of 72 hours or less in duration and limited to trades between ports or terminals agreed by the Society, provided that oily mixtures are retained on board for subsequent discharge to reception facilities
   - carrying products which through their physical properties inhibit effective product/water separation and monitoring, for which the control of discharge is to be effected by the retention of residues on board with discharge of all contaminated washings to reception facilities

b) Where, in the view of the Society, the equipment is not obtainable for the monitoring of discharge of oil refined products (white oils), compliance with such requirements may be waived provided that discharge is performed only in accordance with the applicable procedures.

5.2 Retention of oil on board

5.2.1 General *(1/1/2012)*

Adequate means are to be provided for transferring the dirty ballast residue and tank washings from the cargo tanks into a slop tank approved by the Society.

5.2.2 Capacity of slop tanks *(1/1/2012)*

The arrangement of the slop tank or combination of slop tanks is to have a capacity necessary to retain the slop generated by tank washings, oil residues and dirty ballast residues. The total capacity of the slop tank or tanks is not to be less than 3% of the oil carrying capacity of the ship, except that the Society may accept:

a) 2% for oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for eductors, without the introduction of additional water into the system

b) 2% where segregated ballast tanks are provided in accordance with Sec 2, [5], or where a cargo tank cleaning system using crude oil washing is fitted in accordance with [4.6]. This capacity may be further reduced to 1,5% for oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for eductors, without introduction of additional water into the system.

Oil tankers of 70 000 tonnes deadweight and above are to be fitted with at least two slop tanks.

5.2.3 Design of slop tanks *(1/1/2012)*

Slop tanks are to be so designed particularly in respect of the position of inlets, outlets, baffles or weirs where fitted, as to avoid excessive turbulence and entrainment of oil or emulsion with the water.

5.3 Pumping, piping and discharge arrangements

5.3.1 Discharge manifold *(1/1/2012)*

In every oil tanker, a discharge manifold for connection to reception facilities for the discharge of dirty ballast water or oil contaminated water is to be located on the open deck on both sides of the ship.

5.3.2 Discharge pipelines *(1/1/2012)*

In every oil tanker, pipelines for the discharge of ballast water or oil contaminated water from cargo tank areas to the sea, where permitted, are to be led to the open deck or to the ship side above the waterline in the deepest ballast condition, except that:

a) segregated ballast and clean ballast may be discharged below the waterline:
   - in ports or at offshore terminals, or
   - at sea by gravity,

   provided that the surface of the ballast water has been examined immediately before the discharge to ensure that no contamination with oil has taken place.

b) on every oil tanker at sea, dirty ballast water or oil contaminated water from tanks in the cargo area, other than slop tanks, may be discharged by gravity below the waterline, provided that sufficient time has elapsed in order to allow oil/water separation to have taken place and the water ballast has been examined immediately before the discharge with an oil/water interface detector, in order to ensure that the height of the interface is such that the discharge does not involve any increased risk of harm to the marine environment.

5.3.3 Discharge stopping *(1/1/2012)*

Means are to be provided for stopping the discharge into the sea of ballast water or oil contaminated water from cargo tank areas, other than those discharges below the waterline permitted under [5.3.2], from a position on the upper deck or above located so that the manifold in use referred to in [5.3.1] and the discharge to the sea from the pipelines referred to in [5.3.2] may be visually observed. Means for stopping the discharge need not be provided at the observation position if a positive communication system such as a telephone or radio system is provided between the observation position and the discharge control position.

5.3.4 Cargo piping connections to sea chests *(1/1/2012)*

On every oil tanker where a sea chest is permanently connected to the cargo pipeline system, it is to be equipped with both a sea chest valve and an inboard isolation valve. In addition to these valves, the sea chest is to be capable of isolation from the cargo piping system whilst the tanker is loading, transporting or discharging cargo by use of a positive means that is to the satisfaction of the Society. Such a positive means is a facility that is installed in the pipeline system in order to prevent the section of pipeline between the sea chest valve and the inboard valve being filled with cargo under all circumstances.

Examples of positive means may take the form of blanks, spectacle blanks, pipeline blinds, evacuation or vacuum systems, or air or water pressure systems. In the event that evacuation or vacuum systems, or air or water pressure systems are used, then they are to be equipped with both a pressure gauge and alarm system to enable the continuous monitoring of the status of the pipeline section, and thereby the valve integrity, between the sea chest and inboard valves.

6 Certification, inspection and testing

6.1 Application

6.1.1 *(1/1/2012)*

The provisions of this Article are related to cargo piping and other equipment fitted in the cargo area. They supplement those given in Pt C, Ch 1, Sec 10, [21] for piping systems.

6.2 Workshop tests

6.2.1 Tests for materials *(1/1/2012)*

Where required in Tab 4, materials used for pipes, valves and fittings are to be subjected to the tests specified in Pt C, Ch 1, Sec 10, [21.3.2].

6.2.2 Inspection of welded joints *(1/1/2012)*

Where required in Tab 4, welded joints are to be subjected to the examinations specified in Pt C, Ch 1, Sec 10, [3.6] for class II pipes.

6.2.3 Hydrostatic testing *(1/1/2012)*

a) Where required in Tab 4, cargo pipes, valves, fittings and pump casings are to be submitted to hydrostatic tests in accordance with the relevant provisions of Pt C, Ch 1, Sec 10, [21.4].

b) Expansion joints and cargo hoses are to be submitted to hydrostatic tests in accordance with the relevant provisions of Pt C, Ch 1, Sec 10, [21.4].

c) Where fitted, bellow pieces of gas-tight penetration glands are to be pressure tested.

6.2.4 Tightness tests *(1/1/2012)*

Tightness of the following devices is to be checked:

- gas-tight penetration glands
- cargo tank P/V and high velocity valves.

Note 1: These tests may be carried out in the workshops or on board.

6.2.5 Check of the safety valves setting *(1/1/2012)*

The setting pressure of the pressure/vacuum valves is to be checked in particular with regard to [4.2.6].

6.2.6 Summary table *(1/1/2012)*

Inspections and tests required for cargo piping and other equipment fitted in the cargo area are summarised in Tab 4.

6.3 Shipboard tests

6.3.1 Pressure test *(1/1/2012)*

a) After installation on board, the cargo piping system is to be checked for leakage under operational conditions.

b) The piping system used in crude oil washing systems is to be submitted to hydrostatic tests in accordance with, App 2, [3.2.1].

6.3.2 Survey of pollution prevention equipment *(1/1/2012)*

Every oil tanker of 150 gross tonnage and above is to be subjected to an initial survey before the ship is put in service, to ensure that the equipment, systems, fittings, arrangements and materials fully comply with the relevant provisions of [4.6] and [5].

Table 4 : Inspection and testing at works *(1/1/2012)*

No.	Item	Tests for materials		Inspections and tests for the products			References
		Y/N **(1)**	Type of material certificate **(2)**	during manufacturing **(1)**	after completion **(1) (3)**	Type of product certificate **(2)**	
1	pipes, valves and fittings of class II (see [3.3.1])	Y	• C where ND>100 mm • W where ND≤100 mm	Y **(4)**	Y	C	[6.2.1] [6.2.1] [6.2.2] [6.2.3]
2	expansion joints and cargo hoses	Y **(5)**	W	N	Y	C	[6.2.1] [6.2.3]
3	cargo pumps	Y	W	Y **(6)**	Y	C	see note **(6)** [6.2.3]
4	gas-tight penetration glands	N		N	Y	C	[6.2.3], [6.2.4]
5	cargo tank P/V and high velocity valves	Y	C	Y	Y	C	[6.2.1] [6.2.2] **(4)** [6.2.3], [6.2.4] [6.2.5]
6	flame arresters	N		N	Y	C	see note **(3)**
7	Oil discharge monitoring and control system	N			Y **(7)**	C	see note **(3)**
8	Oil/water interface detector	N			Y **(7)**	C	see note **(3)**

(1) Y = required, N = not required.
(2) C = class certificate, W = works' certificate.
(3) includes the checking of the rule characteristics according to the approved drawings.
(4) only in the case of welded construction.
(5) if metallic.
(6) inspection during manufacturing is to be carried out according to a program approved by the Society.
(7) may also be carried out on board.

7 Steering gear

7.1 General

7.1.1 *(1/1/2012)*

In addition to the provisions of Pt C, Ch 1, Sec 11, the steering gear of **oil tankers** of 10000 gross tonnage and above is to comply with the requirements of [7].

The provision above also applies to **FLS tankers** of 10000 gross tonnage and above carrying flammable cargoes.

7.2 Design of the steering gear

7.2.1 *(1/1/2012)*

Every tanker of 10 000 gross tonnage and upwards is, subject to the provisions of [7.3], to comply with the following:

a) *the main steering gear is to be so arranged that in the event of loss of steering capability due to a single failure in any part of one of the power actuating systems of the main steering gear, excluding the tiller, quadrant or components serving the same purpose, or seizure of the rudder actuators, steering capability is to be regained in not more than 45 s after the loss of one power actuating system;*

b) *the main steering gear is to comprise either:*

   1) *two independent and separate power actuating systems, each capable of meeting the requirements of Pt C, Ch 1, Sec 11, [3.2.1]; or*

   2) *at least two identical power actuating systems which, acting simultaneously in normal operation, are to be capable of meeting the requirements of Pt C, Ch 1, Sec 11, [3.2.1]. Where necessary to comply with this requirement, interconnection of hydraulic power actuating systems is to be provided. Loss of hydraulic fluid from one system is to be capable of being detected and the defective system automatically isolated so that the other actuating system or systems remain(s) fully operational;*

c) *steering gear other than that of the hydraulic type is to achieve equivalent standards.*

7.3 Alternative design for ships of less than 100 000 tonnes deadweight

7.3.1 General *(1/1/2012)*

For tankers of 10 000 gross tonnage and upwards, but of less than 100 000 tonnes deadweight, solutions other than those set out in [7.2], which need not apply the single failure criterion to the rudder actuator or actuators, may be permitted provided that an equivalent safety standard is achieved and that:

a) *following loss of steering capability due to a single failure of any part of the piping system or in one of the power units, steering capability is regained within 45 s; and*

b) *where the steering gear includes only a single rudder actuator, special consideration is given to stress analysis for the design including fatigue analysis and fracture mechanics analysis, as appropriate, to the material used, to the installation of sealing arrangements and to testing and inspection and to the provision of effective maintenance.*

7.3.2 Materials *(1/1/2012)*

Parts subject to internal hydraulic pressure or transmitting mechanical forces to the rudder stock are to be made of duly tested ductile materials complying with recognised standards. Materials for pressure retaining components are to be in accordance with recognised pressure vessel standards. These materials are not to have an elongation of less than 12 per cent or a tensile strength in excess of 650 N/mm^2.

7.3.3 Design *(1/1/2012)*

a) *Design pressure*

   The design pressure is assumed to be at least equal to the greater of the following:

   1) *1,25 times the maximum working pressure to be expected under the operating conditions required in Pt C, Ch 1, Sec 11, [3.3.1],*

   2) *the relief valve setting.*

b) *Analysis*

   1) *The manufacturers of rudder actuators are to submit detailed calculations showing the suitability of the design for the intended service.*

   2) *A detailed stress analysis of the pressure retaining parts of the actuator is to be carried out to determine the stress at the design pressure.*

   3) *Where considered necessary because of the design complexity or manufacturing procedures, a fatigue analysis and fracture mechanics analysis may be required. In connection with the analyses, all foreseen dynamic loads are to be taken into account. Experimental stress analysis may be required in addition to, or in lieu of, theoretical calculations depending on the complexity of the design.*

c) *Allowable stresses*

   For the purpose of determining the general scantlings of parts of rudder actuators subject to internal hydraulic pressure, the allowable stresses are not to exceed:

   - $\sigma_m \le f$
   - $\sigma_l \le 1,5.f$
   - $\sigma_b \le 1,5.f$
   - $\sigma_l + \sigma_b \le 1,5.f$
   - $\sigma_m + \sigma_b \le 1,5.f$

   where:

   σ_m : *Equivalent primary general membrane stress*

   σ_l : *Equivalent primary local membrane stress*

   σ_b : *Equivalent primary bending stress*

   f : *the lesser of σ_B/A or σ_y/B*

   σ_B : *Specified minimum tensile strength of material at ambient temperature*

   σ_y : *Specified minimum yield stress or 0,2 per cent proof stress of material at ambient temperature*

A : *equal to:*

- *4 for steel*
- *4,6 for cast steel*
- *5,8 for nodular cast iron*

B : *equal to:*

- *2 for steel*
- *2,3 for cast steel*
- *3,5 for nodular cast iron*

d) Burst test

1) Pressure retaining parts not requiring fatigue analysis and fracture mechanics analysis may be accepted on the basis of a certified burst test at the discretion of the Society and the detailed stress analysis required by [7.3.3], item b), need not be provided.

2) The minimum bursting pressure is to be calculated as follows:

$$P_b = P \cdot A \cdot \frac{\sigma_{Ba}}{\sigma_B}$$

where:

P_b : *Minimum bursting pressure*

P : *Design pressure as defined in [7.3.3], item a)*

A : *as from [7.3.3], item c)*

σ_{Ba} : *Actual tensile strength*

σ_B : *Tensile strength as defined in [7.3.3], item c).*

7.3.4 Construction details *(1/1/2012)*

a) General

The construction is to be such as to minimise the local concentration of stress.

b) Welds

1) The welding details and welding procedures are to be approved.

2) All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be full penetration type or of equivalent strength.

c) Oil seals

1) Oil seals between non-moving parts, forming part of the external pressure boundary, are to be of the metal upon metal type or of an equivalent type.

2) Oil seals between moving parts, forming part of the external pressure boundary, are to be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage may be accepted at the discretion of the Society.

d) Isolating valves

Isolating valves are to be fitted at the connection of pipes to the actuator, and are to be directly mounted on the actuator.

e) Relief valves

Relief valves for protecting the rudder actuator against overpressure as required in Pt C, Ch 1, Sec 11, [2.2.5] are to comply with the following:

1) the setting pressure is not to be less than 1,25 times the maximum working pressure expected under operating conditions required in Pt C, Ch 1, Sec 11, [3.3.1], item b),

2) the minimum discharge capacity of the relief valves is not to be less than the total capacity of all pumps which provide power for the actuator, increased by 10 per cent. Under such conditions, the rise in pressure is not to exceed 10 per cent of the setting pressure. In this regard, due consideration is to be given to extreme foreseen ambient conditions in respect of oil viscosity.

7.3.5 Inspection and testing *(1/1/2012)*

a) Non-destructive testing

The rudder actuator is to be subjected to suitable and complete non-destructive testing to detect both surface flaws and volumetric flaws. The procedure and acceptance criteria for non-destructive testing is to be in accordance with requirements of recognised standards. If found necessary, fracture mechanics analysis may be used for determining maximum allowable flaw size.

b) Other testing

1) Tests, including hydrostatic tests, of all pressure parts at 1,5 times the design pressure are to be carried out.

2) When installed on board the ship, the rudder actuator is to be subjected to a hydrostatic test and a running test.

8 Specific requirements FLS tanker

8.1 Application

8.1.1 *(1/1/2012)*

The provisions of this Article, derived from Annex II of the MARPOL 73/78 Convention as amended, are related to the prevention of pollution by noxious liquid substances. They apply as follows:

a) Where the ship is granted only the service notation FLS tanker, these provisions replace those of [5] related to the prevention of pollution by cargo oil.

b) Where the ship is granted both service notations oil tanker-FLS tanker, these provisions are additional to those of [5].

8.2 Design requirements

8.2.1 General *(1/1/2012)*

The requirements of [8.2] apply to ships carrying category Z substances (see App 4, Tab 1).

8.2.2 Cargo piping and pumping system *(1/1/2012)*

The pumping and piping arrangement is to ensure that each tank does not retain a quantity of residue in excess of 75 litres in the tank and its associated piping. A performance test shall be carried out in accordance with Appendix 5 of Annex II of MARPOL 73/78 Convention as amended.

8.2.3 Underwater discharge *(1/1/2012)*

An underwater discharge outlet (or outlets) shall be fitted.

The underwater discharge outlet (or outlets) shall be located within the cargo area in the vicinity of the turn of the bilge and shall be so arranged as to avoid the re-intake of residue/water mixtures by the ship's seawater intakes.

The underwater discharge outlet arrangement is to be such that the residue/water mixture discharged into the sea will not pass through the ship's boundary layer. To this end, when the discharge is made normal to the ship's shell plating, the minimum diameter of the discharge outlet is governed by the following equation:

$$d = \frac{Q_d}{5L_d}$$

where:

- d : Minimum diameter of the discharge outlet (m)
- L_d : Distance from the forward perpendicular to the discharge outlet (m)
- Q_d : The maximum rate selected at which the ship may discharge a residue/water mixture through the outlet (m^3/h).

When the discharge is directed at an angle to the ship's shell plating, the above relationship is to be modified by substituting for Q_d the component of Q_d which is normal to the ship's shell plating.

8.2.4 Ventilation equipment *(1/1/2012)*

a) If residues from cargo tanks are removed by means of ventilation, ventilation equipment meeting the following provisions is to be provided.

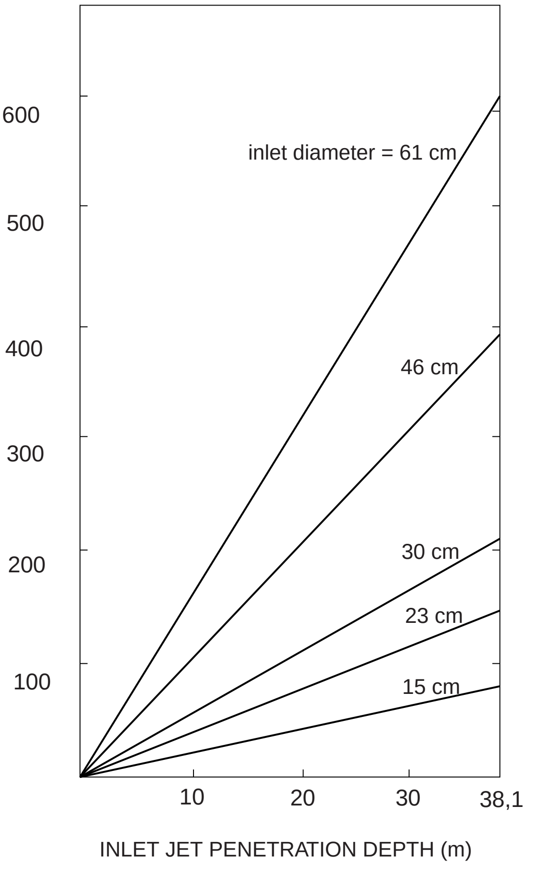
Note 1: Ventilation procedures may be applied only to those substances having a vapour pressure greater than 5 x 10^3 Pa at 20°C.

b) The ventilation equipment is to be capable of producing an air jet which can reach the tank bottom. Fig 2 may be used to evaluate the adequacy of ventilation equipment used for ventilating a tank of given depth.

c) The ventilation equipment is to be placed in the tank opening closest to the tank sump or suction point.

d) When practicable, the ventilation equipment is to be positioned so that the air jet is directed at the tank sump or suction point and impingement of the air jet on tank structural members is to be avoided as far as possible.

Figure 2 : Minimum flow rate as a function of jet penetration depth *(1/1/2012)*



Note: Jet penetration depth is to be compared against tank height.

SECTION 5 MACHINERY AND CARGO SYSTEMS FOR OIL TANKER ESP FLASHPOINT > 60°, OIL TANKER ESP CSR FLASHPOINT > 60°, ASPHALT TANKER, ASPHALT TANKER ESP, FLS TANKER FLASHPOINT > 60°

1 General

1.1 Application

1.1.1 *(1/1/2012)*

The requirements of this Section apply to ships having the service notation:

- **oil tanker ESP, flashpoint > 60°C**
- **oil tanker ESP CSR, flashpoint > 60°C**
- **asphalt tanker**
- **asphalt tanker ESP**
- **FLS tanker**, **flashpoint > 60°C**

intended to carry products having flashpoint > 60°C.

The requirements in [2.1.3], [2.3.1], [2.3.3], [2.3.4], [2.3.5], [3.4.4], [5] and [6.3.2] derived from MARPOL Annex I regulations apply only to ships having the service notation **oil tanker ESP, flashpoint > 60°C** or **oil tanker ESP CSR, flashpoint > 60°C** (named oil tankers in this Section) or **asphalt tanker** or **asphalt tanker ESP** (named asphalt tanker in this Section).

The ships having the service notation **FLS tanker**, **flashpoint > 60°C** are named **FLS tankers** in this Section.

1.1.2 Additional requirements *(1/1/2012)*

Additional requirements are provided in:

- [8] for ships having the service notation **asphalt tanker** or **asphalt tanker ESP**
- [9] for ships intended to carry substances of pollution category Z.

1.2 Documents to be submitted

1.2.1 *(1/1/2012)*

The documents listed in Tab 1 are to be submitted for approval in four copies.

2 Piping systems other than cargo piping system

2.1 General

2.1.1 Materials *(1/1/2012)*

a) Materials are to comply with the provisions of Pt C, Ch 1, Sec 10.

b) Spheroidal graphite cast iron may be accepted for bilge and ballast piping.

2.1.2 Independence of piping systems *(1/1/2012)*

a) Fuel oil systems are to:

- be independent from the cargo piping system
- have no connections with pipelines serving cargo or slop tanks.

2.1.3 Passage through cargo tanks and slop tanks *(1/1/2012)*

a) Unless otherwise specified, bilge, ballast and fuel oil systems serving spaces located outside the cargo area are not to pass through cargo tanks or slop tanks. They may pass through ballast tanks or void spaces located within the cargo area.

b) Where expressly permitted, ballast pipes passing through cargo tanks are to fulfil the following provisions:

- they are to have welded or heavy flanged joints the number of which is kept to a minimum
- they are to be of extra-reinforced wall thickness as per Pt C, Ch 1, Sec 10, Tab 5
- they are to be adequately supported and protected against mechanical damage.

2.2 Bilge system

2.2.1 Draining of spaces located outside the cargo area *(1/1/2012)*

For bilge draining of spaces located outside the cargo area, refer to Pt C, Ch 1, Sec 10, [6].

Table 1 : Documents to be submitted *(1/1/2012)*

No.	Description of the document **(1)**
1	Diagram of cargo piping system
2	Diagram of the cargo tank venting system with indication of the outlet position
3	Diagram of the cargo tank level gauging system with overfill safety arrangements
4	Diagram of the cargo tank cleaning system
5	Diagram of the bilge and ballast systems serving the spaces located in the cargo area
6	Diagram of the cargo heating systems
(1) Diagrams are also to include, where applicable, the (local and remote) control and monitoring systems and automation systems.	

2.2.2 Draining of pump rooms *(1/1/2012)*

a) Arrangements are to be provided to drain the pump rooms by means of power pumps or bilge ejectors.

Note 1: On tankers of less than 500 gross tonnage, the pump rooms may be drained by means of hand pumps with a suction diameter of not less than 50 mm.

b) Cargo pumps or stripping pumps may be used for draining cargo pump rooms provided that:

- a screw-down non-return valve is fitted on the bilge suctions.

c) Bilge pipe internal diameter is not to be less than 50 mm.

d) High liquid level in the bilges is to activate an audible and visual alarm in the cargo control room and on the navigation bridge.

2.2.3 Drainage of hold spaces, cofferdams and void spaces located within the cargo area *(1/1/2012)*

Hold spaces, cofferdams and void spaces located within the cargo area and not intended to be filled with water ballast are to be fitted with suitable means of drainage.

2.3 Ballast system

2.3.1 General *(1/1/2012)*

a) Every oil tanker certified as a product carrier of 30 000 tonnes deadweight and above is to be provided with segregated ballast tanks.

b) Except where expressly permitted, ballast systems serving segregated ballast tanks are to be completely separated from the cargo oil and fuel oil systems.

c) In oil tankers of 150 gross tonnage and above, no ballast water is normally to be carried in any fuel oil tank; see Pt C, Ch 1, Sec 10, [7.1.3].

d) In oil tankers certified as product carriers of 30 000 tonnes deadweight and above, no ballast water is to be carried in cargo tanks, except in exceptional cases.

2.3.2 Pumping arrangements for ballast tanks within the cargo area *(1/1/2012)*

Segregated ballast tanks located within the cargo area are to be served by two different means. At least one of these means is to be a pump or an eductor used exclusively for dealing with ballast. The ballast system serving the spaces located outside the cargo area may be used for this purpose.

2.3.3 Emergency discharge of segregated ballast *(1/1/2012)*

Provisions may be made for emergency discharge of the segregated ballast by means of a connection to a cargo pump through a detachable spool piece provided that:

- non-return valves are fitted on the segregated ballast connections to prevent the passage of oil to the ballast tank, and
- shut-off valves are fitted to shut off the cargo and ballast lines before the spool piece is removed.

The detachable spool piece is to be placed in a conspicuous position in the pump room and a permanent warning notice restricting its use is to be displayed in a conspicuous position adjacent to it.

2.3.4 Carriage of ballast water in cargo tanks *(1/1/2012)*

a) Provisions are to be made for filling cargo tanks with sea water, where permitted. Such ballast water is to be processed and discharged using the equipment referred to in [5].

b) The sea water inlets and overboard discharges serving cargo tanks for the purpose of a) are not to have any connection with the ballast system of segregated ballast tanks.

c) Cargo pumps may be used for pumping ballast water to or from the cargo tanks, provided two shut-off valves are fitted to isolate the cargo piping system from the sea inlets and overboard discharges. See also [5.4.4].

d) Ballast pumps serving segregated ballast tanks may be used for filling the cargo tanks with sea water provided that the connection is made on the top of the tanks and consists of a detachable spool piece and a screw-down non-return valve to avoid siphon effects.

2.3.5 Ballast pipes passing through tanks *(1/1/2012)*

a) In oil tankers and on asphalt tankers of 600 tonnes deadweight and above, ballast piping is not to pass through cargo tanks except in the case of short lengths of piping complying with [2.1.3], item b).

b) Sliding type couplings are not to be used for expansion purposes where ballast lines pass through cargo tanks. Expansion bends only are permitted.

2.3.6 Integrated cargo and ballast system *(1/1/2012)*

The requirements for integrated cargo and ballast systems are given in [3.5].

2.4 Scupper pipes

2.4.1 *(1/1/2012)*

Scupper pipes are not to pass through cargo tanks except, where this is impracticable, in the case of short lengths of piping complying with the following provisions:

- they are of steel
- they have only welded or heavy flanged joints the number of which is kept to a minimum
- they are of substantial wall thickness as per Pt C, Ch 1, Sec 10, Tab 22, column 1.

2.5 Heating systems intended for cargo

2.5.1 General *(1/1/2012)*

Heating systems intended for cargo are to comply with the relevant requirements of Pt C, Ch 1, Sec 10.

3 Cargo pumping and piping systems

3.1 General

3.1.1 *(1/1/2012)*

A complete system of pumps and piping is to be fitted for handling the cargo.

3.2 Cargo pumping system

3.2.1 Number and location of cargo pumps *(1/1/2012)*

Each cargo tank is to be served by at least two separate fixed means of discharging and stripping. However, for tanks fitted with an individual submerged pump, the second means may be portable.

3.2.2 Use of cargo pumps *(1/1/2012)*

a) Except where expressly permitted in [2.2] and [2.3], cargo pumps are to be used exclusively for handling the liquid cargo and are not to have any connections to compartments other than cargo tanks.

b) Subject to their performance, cargo pumps may be used for tank stripping.

c) Cargo pumps may be used, where necessary, for the washing of cargo tanks.

3.2.3 Cargo pump drive *(1/1/2012)*

Pumps with a submerged electric motor are not permitted in cargo tanks.

Note 1: The provisions of this requirement also apply to stripping pumps and ballast pumps.

3.2.4 Design of cargo pumps *(1/1/2012)*

a) Materials of cargo pumps are to be suitable for the products carried.

b) The delivery side of cargo pumps is to be fitted with relief valves discharging back to the suction side of the pumps (bypass) in closed circuit. Such relief valves may be omitted in the case of centrifugal pumps with a maximum delivery pressure not exceeding the design pressure of the piping, with the delivery valve closed.

3.2.5 Monitoring of cargo pumps *(1/1/2012)*

Cargo pumps are to be monitored as required in Tab 2.

3.2.6 Control of cargo pumps *(1/1/2012)*

Cargo pumps are to be capable of being stopped from:

- a position outside the pump room, and
- a position next to the pumps.

3.3 Cargo piping design

3.3.1 General *(1/1/2012)*

a) Unless otherwise specified, cargo piping is to be designed and constructed according to the requirements of Pt C, Ch 1, Sec 10 applicable to piping systems of:
   - class III, in the case of oil tankers and asphalt tankers
   - class II, in the case of FLS tankers, with the exception of cargo pipes and accessories having an open end or situated inside cargo tanks, for which class III may be accepted.

b) For tests, refer to [6].

Table 2 : Monitoring of cargo pumps *(1/1/2012)*

Equipment, parameter	Alarm	Indication **(1)**	Comments
pump, discharge pressure		L	• on the pump **(2)**, or • next to the unloading control station

(1) L = low
(2) and next to the driving machine if located in a separate compartment

3.3.2 Materials *(1/1/2012)*

a) Cargo piping is, in general, to be made of steel or cast iron.

b) Valves, couplings and other end fittings of cargo pipe lines for connection to hoses are to be of steel or other suitable ductile material.

c) Spheroidal graphite cast iron may be used for cargo oil piping.

d) Grey cast iron may be accepted for cargo oil lines:

- within cargo tanks, and
- on the weather deck for pressure up to 1,6 MPa.

It is not to be used for manifolds and their valves of fittings connected to cargo handling hoses.

e) Plastic pipes may be used in the conditions specified in Pt C, Ch 1, App 3. Arrangements are to be made to avoid the generation of static electricity.

3.3.3 Connection of cargo pipe lengths *(1/1/2012)*

Cargo pipe lengths may be connected either by means of welded joints or, unless otherwise specified, by means of flange connections.

3.3.4 Expansion joints *(1/1/2012)*

a) Where necessary, cargo piping is to be fitted with expansion joints or bends.

b) Expansion joints including bellows are to be of a type approved by the Society.

c) Expansion joints made of non-metallic material may be accepted only inside tanks and provided they are:

- of an approved type
- designed to withstand the maximum internal and external pressure
- electrically conductive
- in oil tankers and asphalt tankers, sliding type couplings are not to be used for expansion purposes where lines for cargo oil pass through tanks for segregated ballast.

d) In **FLS tanker**, slip joints are not to be used for cargo piping systems with the exception of pipe sections inside cargo tanks served by such sections.

3.3.5 Valves with remote control *(1/1/2012)*

a) Valves with remote control are to comply with Pt C, Ch 1, Sec 10, [2.7.3].

b) Submerged valves are to be remote controlled. In the case of a hydraulic remote control system, control boxes are to be provided outside the tank, in order to permit the emergency control of valves.

c) Valve actuators located inside cargo tanks are not to be operated by means of compressed air.

3.3.6 Cargo hoses *(1/1/2012)*

a) Cargo hoses are to be of a type approved by the Society for the intended conditions of use.

b) Hoses subject to tank pressure or pump discharge pressure are to be designed for a bursting pressure not less than 4 times the maximum pressure under cargo transfer conditions.

c) The ohmic electrical resistance of cargo hoses is not to exceed $10^6\ \Omega$.

3.4 Cargo piping arrangement and installation

3.4.1 Cargo pipes passing through tanks or compartments *(1/1/2012)*

a) Cargo piping is not to pass through tanks or compartments located outside the cargo area.

b) Cargo piping and similar piping to cargo tanks is not to pass through ballast tanks except in the case of short lengths of piping complying with [2.1.3], item b).

c) Cargo piping may pass through vertical fuel oil tanks adjacent to cargo tanks on condition that the provisions of [2.1.3], item b) are complied with.

d) Piping through cargo tanks, see also Ch 7, Sec 2, [3.1.4].

3.4.2 Cargo piping passing through bulkheads *(1/1/2012)*

Cargo piping passing through bulkheads is to be so arranged as to preclude excessive stresses at the bulkhead. Bolted flanges are not to be used in the bulkhead.

3.4.3 Valves *(1/1/2012)*

a) Stop valves are to be provided to isolate each tank.

b) A stop valve is to be fitted at each end of the cargo manifold.

c) When a cargo pump in the cargo pump room serves more than one cargo tank, a stop valve is to be fitted in the cargo pump room on the line leading to each tank.

d) Main cargo oil valves located in the cargo pump room below the floor gratings are to be remote controlled from a position above the floor.

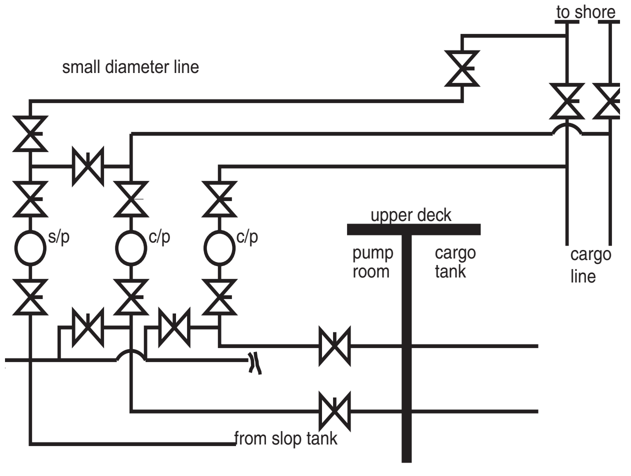
3.4.4 Draining of cargo pumps and oil lines *(1/1/2012)*

Every oil tanker and asphalt carrier required to be provided with segregated ballast tanks is to comply with the following requirements:

a) it is to be equipped with oil piping so designed and installed that oil retention in the lines is minimised, and

b) means are to be provided to drain all cargo pumps and all oil lines at the completion of cargo discharge, where necessary by connection to a stripping device. The line and pump drainings are to be capable of being discharged both ashore and to a cargo tank or slop tank. For discharge ashore, a special small diameter line having a cross-sectional area not exceeding 10% of the main cargo discharge line is to be provided and is to be connected on the downstream side of the tanker's deck manifold valves, both port and starboard, when the cargo is being discharged; see Fig 1.

Figure 1 : Connection of small diameter line to the manifold valve *(1/1/2012)*



3.5 Integrated cargo and ballast systems design

3.5.1 Functional requirements *(1/1/2012)*

The operation of cargo and/or ballast systems may be necessary, under certain emergency circumstances or during the course of navigation, to enhance the safety of tankers.

As such, measures are to be taken to prevent cargo and ballast pumps becoming inoperative simultaneously due to a single failure in the integrated cargo and ballast system, including its control and safety systems. The same criteria apply to control systems of cargo and ballast valves.

3.5.2 Design features *(1/1/2012)*

The following design features are, inter alia, to be fitted:

a) the emergency stop circuits of the cargo and ballast systems are to be independent from the circuits for the control systems. A single failure in the control system circuits or the emergency stop circuits is not to render the integrated cargo and ballast system inoperative;

b) manual emergency stops of the cargo pumps are to be arranged such that they do not cause the shutdown of the power pack making ballast pumps inoperable;

c) the control systems are to be provided with backup power supply, which may be satisfied by a duplicate power supply from the main switchboard. The failure of any power supply is to provide audible and visible alarm activation at each location where the control panel is fitted.

d) in the event of failure of the automatic or remote control systems, a secondary means of control is to be made available for the operation of the integrated cargo and ballast system. This is to be achieved by manual overriding and/or redundant arrangements within the control systems.

4 Cargo tanks and fittings

4.1 Application

4.1.1 *(1/1/2012)*

The provisions of Article [4] apply to cargo tanks and slop tanks.

4.2 Cargo tank venting

4.2.1 *(1/1/2012)*

The relevant provisions of Pt C, Ch 1, Sec 10, [9] and Pt C, Ch 1, Sec 10, [11] are to be complied with.

Tank venting systems are to open to the atmosphere at a height of at least 760 mm above the weather deck. If the cargo is carried at a temperature exceeding the flashpoint by more than 15°C, this height is to be increased to 2,4 m.

Tanks may be fitted with venting systems of the open type provided with a flame screen. For ships carrying bulk cargoes with flashpoint > 100°C, the flame screen may be omitted.

4.3 Protection against tank overload

4.3.1 General *(1/1/2012)*

a) Provisions are to be made to guard against liquid rising in the venting system of cargo or slop tanks to a height which would exceed the design head of the tanks. This is to be accomplished by high level alarms or overflow control systems or other equivalent means, together with gauging devices and cargo tank filling procedures.

Note 1: For FLS tankers, only high level alarms are permitted.

b) Sufficient ullage is to be left at the end of tank filling to permit free expansion of liquid during carriage.

c) High level alarms, overflow control systems and other means referred to in a) are to be independent of the gauging systems referred to in [4.4].

4.3.2 High level alarms *(1/1/2012)*

a) High level alarms are to be type approved.

b) High level alarms are to give an audible and visual signal at t he control station, where provided.

4.3.3 Other protection systems *(1/1/2012)*

a) Where the tank level gauging systems, cargo and ballast pump control systems and valve control systems are centralised in a single location, the provisions of [4.4.1] may be complied with by the fitting of a level gauge for the indication of the end of loading, in addition to that required for each tank under [4.4]. The readings of both gauges for each tank are to be as near as possible to each other and so arranged that any discrepancy between them can be easily detected.

b) Where a tank can be filled only from other tanks, the provisions of [4.4.1] are considered as complied with.

4.4 Tank washing systems

4.4.1 General *(1/1/2012)*

a) Adequate means are to be provided for cleaning the cargo tanks.

b) For FLS tankers carrying category Z substances, the provisions of [9.2.2] are to be applied.

4.4.2 Washing machines *(1/1/2012)*

a) Tank washing machines are to be of a type approved by the Society.

b) Washing machines are to be made of steel or other electricity conducting materials with a limited propensity to produce sparks on contact.

4.4.3 Washing pipes *(1/1/2012)*

Washing pipes are to be built, fitted, inspected and tested in accordance with the applicable requirements of Pt C, Ch 1, Sec 10, depending on the kind of washing fluid or water.

4.4.4 Installation of washing systems *(1/1/2012)*

Tank cleaning openings are not to be arranged in enclosed spaces.

5 Prevention of pollution by cargo oil

5.1 General

5.1.1 Application *(1/1/2012)*

Unless otherwise specified, the provisions of [5.2] and [5.3] apply only to oil tankers of 150 gross tonnage and above.

5.1.2 Provisions for oil tankers of less than 150 gross tonnage *(1/1/2012)*

The control of discharge for **oil tankers** of less than 150 gross tonnage is to be effected by the retention of oil on board with subsequent discharge of all contaminated washings to reception facilities unless adequate arrangements are made to ensure that the discharge of any effluent into the sea, where allowed, is effectively monitored to ensure that the total quantity of oil discharged into the sea does not exceed 1/30 000 of the total quantity of the particular cargo of which the residue formed a part.

5.1.3 Exemptions *(1/1/2012)*

a) The provisions of [5.2] and [5.3] may be waived in the following cases:
   - oil tankers engaged exclusively on voyages within 50 miles from the nearest land and of 72 hours or less in duration and limited to trades between ports or terminals agreed by the Society, provided that oily mixtures are retained on board for subsequent discharge to reception facilities
   - ooil tankers carrying products which through their physical properties inhibit effective product/water separation and monitoring, for which the control of discharge is to be effected by the retention of residues on board with discharge of all contaminated washings to reception facilities
   - asphalt tankers.

b) Where, in the view of the Society, the equipment referred to in [5.3.1] and [5.3.2] is not obtainable for the monitoring of discharge of oil refined products (white oils), compliance with such requirements may be waived provided that discharge is performed only in accordance with the applicable procedures.

5.2 Retention of oil on board

5.2.1 General *(1/1/2012)*

Adequate means are to be provided for transferring the dirty ballast residue and tank washings from the cargo tanks into a slop tank approved by the Society.

5.2.2 Capacity of slop tanks *(1/1/2012)*

The arrangement of the slop tank or combination of slop tanks is to have a capacity necessary to retain the slop generated by tank washings, oil residues and dirty ballast residues. The total capacity of the slop tank or tanks is not to be less than 3% of the oil carrying capacity of the ship, except that the Society may accept:

a) 2% for oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for eductors, without the introduction of additional water into the system

b) 2% where segregated ballast tanks are provided in accordance with Sec 2, [5], or where a cargo tank cleaning system using crude oil washing is fitted in accordance with [4.4]. This capacity may be further reduced to 1,5% for oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for eductors, without introduction of additional water into the system.

Oil tankers of 70 000 tonnes deadweight and above are to be fitted with at least two slop tanks.

5.2.3 Design of slop tanks *(1/1/2012)*

Slop tanks are to be so designed particularly in respect of the position of inlets, outlets, baffles or weirs where fitted, as to avoid excessive turbulence and entrainment of oil or emulsion with the water.

5.3 Oil discharge monitoring and control system

5.3.1 General *(1/1/2012)*

a) An oil discharge monitoring and control system is to be fitted.

b) A manually operated alternative method is to be provided.

5.3.2 Design of the discharge monitoring and control system *(1/1/2012)*

a) The discharge monitoring and control system is to be of a type approved in compliance with the provisions of IMO Resolution A.586(14).

b) The discharge monitoring and control system is to be fitted with a recording device to provide a continuous record of the discharge in litres per nautical mile and total quantity discharged, or the oil content and rate of discharge. This record is to be identifiable as regards time and date.

c) The oil discharge monitoring and control system is to come into operation when there is any discharge of effluent into the sea and is to be such as will ensure that any discharge of oily mixture is automatically stopped when the instantaneous rate of discharge of oil content exceeds 30 litres per nautical mile.

d) Any failure of the monitoring and control system is to stop the discharge.

5.3.3 Oil/water interface detectors *(1/1/2012)*

Effective oil/water interface detectors approved by the Society are to be provided for a rapid and accurate determination of the oil/water interface in slop tanks and are to be available for use in other tanks where the separation of oil and water is effected and from which it is intended to discharge effluent directly to the sea.

5.4 Pumping, piping and discharge arrangements

5.4.1 Discharge manifold *(1/1/2012)*

In every oil tanker and asphalt tanker, a discharge manifold for connection to reception facilities for the discharge of dirty ballast water or oil contaminated water is to be located on the open deck on both sides of the ship.

5.4.2 Discharge pipelines *(1/1/2012)*

In every oil tanker and asphalt tanker , pipelines for the discharge of ballast water or oil contaminated water from cargo tank areas to the sea, where permitted, are to be led to the open deck or to the ship side above the waterline in the deepest ballast condition, except that:

a) segregated ballast and clean ballast may be discharged below the waterline:
   - in ports or at offshore terminals, or
   - at sea by gravity,

   provided that the surface of the ballast water has been examined immediately before the discharge to ensure that no contamination with oil has taken place.

b) on every oil tanker and asphalt tanker at sea, dirty ballast water or oil contaminated water from tanks in the cargo area, other than slop tanks, may be discharged by gravity below the waterline, provided that sufficient time has elapsed in order to allow oil/water separation to have taken place and the water ballast has been examined immediately before the discharge with an oil/water interface detector referred to in [5.3.3], in order to ensure that the height of the interface is such that the discharge does not involve any increased risk of harm to the marine environment.

5.4.3 Discharge stopping *(1/1/2012)*

On every oil tanker and asphalt tanker means are to be provided for stopping the discharge into the sea of ballast water or oil contaminated water from cargo tank areas, other than those discharges below the waterline permitted under [5.4.2], from a position on the upper deck or above located so that the manifold in use referred to in [5.4.1] and the discharge to the sea from the pipelines referred to in [5.4.2] may be visually observed. Means for stopping the discharge need not be provided at the observation position if a positive communication system such as a telephone or radio system is provided between the observation position and the discharge control position.

5.4.4 Cargo piping connections to sea chests *(1/1/2012)*

On every oil tanker and asphalt tanker where a sea chest is permanently connected to the cargo pipeline system, it is to be equipped with both a sea chest valve and an inboard isolation valve. In addition to these valves, the sea chest is to be capable of isolation from the cargo piping system whilst the tanker is loading, transporting or discharging cargo by use of a positive means that is to the satisfaction of the Society. Such a positive means is a facility that is installed in the pipeline system in order to prevent the section of pipeline between the sea chest valve and the inboard valve being filled with cargo under all circumstances.

Examples of positive means may take the form of blanks, spectacle blanks, pipeline blinds, evacuation or vacuum systems, or air or water pressure systems. In the event that evacuation or vacuum systems, or air or water pressure systems are used, then they are to be equipped with both a pressure gauge and alarm system to enable the continuous monitoring of the status of the pipeline section, and thereby the valve integrity, between the sea chest and inboard valves.

6 Certification, inspection and testing

6.1 Application

6.1.1 *(1/1/2012)*

The provisions of this Article are related to cargo piping and other equipment fitted in the cargo area. They supplement those given in Pt C, Ch 1, Sec 10, [21] for piping systems.

6.2 Workshop tests

6.2.1 Tests for materials *(1/1/2012)*

Where required in Tab 3, materials used for pipes, valves and fittings are to be subjected to the tests specified in Pt C, Ch 1, Sec 10, [21.3.2].

6.2.2 Inspection of welded joints *(1/1/2012)*

Where required in Tab 3, welded joints are to be subjected to the examinations specified in Pt C, Ch 1, Sec 10, [3.6] for class II pipes.

6.2.3 Hydrostatic testing *(1/1/2012)*

a) Where required in Tab 3, cargo pipes, valves, fittings and pump casings are to be submitted to hydrostatic tests in accordance with the relevant provisions of Pt C, Ch 1, Sec 10, [21.4].

b) Expansion joints and cargo hoses are to be submitted to hydrostatic tests in accordance with the relevant provisions of Pt C, Ch 1, Sec 10, [21.4].

c) Where fitted, bellow pieces of gas-tight penetration glands are to be pressure tested.

6.2.4 Tightness tests *(1/1/2012)*

Tightness of the following devices is to be checked:

- gas-tight penetration glands
- cargo tank P/V and high velocity valves.

Note 1: These tests may be carried out in the workshops or on board.

6.2.5 Check of the safety valves setting *(1/1/2012)*

The setting pressure of the pressure/vacuum valves is to be checked in particular with regard to Sec 4, [4.2.6].

6.2.6 Summary table *(1/1/2012)*

Inspections and tests required for cargo piping and other equipment fitted in the cargo area are summarised in Tab 3.

6.3 Shipboard tests

6.3.1 Pressure test *(1/1/2012)*

a) After installation on board, the cargo piping system is to be checked for leakage under operational conditions.

b) The piping system used in crude oil washing systems is to be submitted to hydrostatic tests in accordance with, App 2, [3.2.1].

6.3.2 Survey of pollution prevention equipment *(1/1/2012)*

Every oil tanker of 150 gross tonnage and above is to be subjected to an initial survey before the ship is put in service, to ensure that the equipment, systems, fittings, arrangements and materials fully comply with the relevant provisions of [4.4] and [5].

7 Steering gear

7.1 General

7.1.1 *(1/1/2012)*

In addition to the provisions of Pt C, Ch 1, Sec 11, the steering gear on oil tankers and asphalt tankers of 10000 gross tonnage and above is to comply with the requirements of [7].

The provision above also applies to ships having the service notation FLS tanker of 10000 gross tonnage and above carrying flammable cargoes.

7.2 Design of the steering gear

7.2.1 *(1/1/2012)*

Every tanker of 10 000 gross tonnage and upwards is, subject to the provisions of [7.3], to comply with the following:

a) the main steering gear is to be so arranged that in the event of loss of steering capability due to a single failure in any part of one of the power actuating systems of the main steering gear, excluding the tiller, quadrant or components serving the same purpose, or seizure of the rudder actuators, steering capability is to be regained in not more than 45 s after the loss of one power actuating system;

b) the main steering gear is to comprise either:

1) two independent and separate power actuating systems, each capable of meeting the requirements of Pt C, Ch 1, Sec 11, [3.2.1]; or

2) at least two identical power actuating systems which, acting simultaneously in normal operation, are to be capable of meeting the requirements of Pt C, Ch 1, Sec 11, [3.2.1]. Where necessary to comply with this requirement, interconnection of hydraulic power actuating systems is to be provided. Loss of hydraulic fluid from one system is to be capable of being detected and the defective system automatically isolated so that the other actuating system or systems remain(s) fully operational;

c) steering gear other than that of the hydraulic type is to achieve equivalent standards.

7.3 Alternative design for ships of less than 100 000 tonnes deadweight

7.3.1 General *(1/1/2012)*

For tankers of 10 000 gross tonnage and upwards, but of less than 100 000 tonnes deadweight, solutions other than those set out in [7.2], which need not apply the single failure criterion to the rudder actuator or actuators, may be permitted provided that an equivalent safety standard is achieved and that:

a) following loss of steering capability due to a single failure of any part of the piping system or in one of the power units, steering capability is regained within 45 s; and

b) where the steering gear includes only a single rudder actuator, special consideration is given to stress analysis for the design including fatigue analysis and fracture mechanics analysis, as appropriate, to the material used, to the installation of sealing arrangements and to testing and inspection and to the provision of effective maintenance.

7.3.2 Materials *(1/1/2012)*

Parts subject to internal hydraulic pressure or transmitting mechanical forces to the rudder stock are to be made of duly tested ductile materials complying with recognised standards. Materials for pressure retaining components are to be in accordance with recognised pressure vessel standards. These materials are not to have an elongation of less than 12 per cent or a tensile strength in excess of 650 N/mm².

Table 3 : Inspection and testing at works *(1/1/2012)*

No.	Item	Tests for materials		Inspections and tests for the products			References
		Y/N **(1)**	Type of material certificate **(2)**	during manufacturing **(1)**	after completion **(1)** **(3)**	Type of product certificate **(2)**	
1	pipes, valves and fittings of class II (see [3.3.1])	Y	• C where ND>100 mm • W where ND≤100 mm	Y **(4)**	Y	C	[6.2.1] [6.2.1] [6.2.2] [6.2.3]
2	expansion joints and cargo hoses	Y **(5)**	W	N	Y	C	[6.2.1] [6.2.3]
3	cargo pumps	Y	W	Y **(6)**	Y	C	see note **(6)** [6.2.3]
4	gas-tight penetration glands	N		N	Y	C	[6.2.3] [6.2.4]
5	cargo tank P/V and high velocity valves	Y	C	Y	Y	C	[6.2.1] [6.2.2] **(4)** [6.2.3] [6.2.4] [6.2.5]
6	flame arresters	N		N	Y	C	see note **(3)**
7	Oil discharge monitoring and control system	N			Y **(7)**	C	see note **(3)**
8	Oil/water interface detector	N			Y **(7)**	C	see note **(3)**

(1) Y = required, N = not required.
(2) C = class certificate, W = works' certificate.
(3) includes the checking of the rule characteristics according to the approved drawings.
(4) only in the case of welded construction.
(5) if metallic.
(6) inspection during manufacturing is to be carried out according to a program approved by the Society.
(7) may also be carried out on board.

7.3.3 Design *(1/1/2012)*

a) *Design pressure*

The design pressure is assumed to be at least equal to the greater of the following:

1) *1,25 times the maximum working pressure to be expected under the operating conditions required in Pt C, Ch 1, Sec 11, [3.3.1],*

2) *the relief valve setting.*

b) *Analysis*

1) *The manufacturers of rudder actuators are to submit detailed calculations showing the suitability of the design for the intended service.*

2) *A detailed stress analysis of the pressure retaining parts of the actuator is to be carried out to determine the stress at the design pressure.*

3) *Where considered necessary because of the design complexity or manufacturing procedures, a fatigue analysis and fracture mechanics analysis may be*

required. In connection with the analyses, all foreseen dynamic loads are to be taken into account. Experimental stress analysis may be required in addition to, or in lieu of, theoretical calculations depending on the complexity of the design.

c) *Allowable stresses*

For the purpose of determining the general scantlings of parts of rudder actuators subject to internal hydraulic pressure, the allowable stresses are not to exceed:

- $\sigma_m \leq f$
- $\sigma_l \leq 1,5.f$
- $\sigma_b \leq 1,5.f$
- $\sigma_l + \sigma_b \leq 1,5.f$
- $\sigma_m + \sigma_b \leq 1,5.f$

where:

σ_m : *Equivalent primary general membrane stress*

σ_l : *Equivalent primary local membrane stress*

σ_b : *Equivalent primary bending stress*

f : *the lesser of* σ_B/A *or* σ_y/B

σ_B : *Specified minimum tensile strength of material at ambient temperature*

σ_y : *Specified minimum yield stress or 0,2 per cent proof stress of material at ambient temperature*

A : *equal to:*
- *4 for steel*
- *4,6 for cast steel*
- *5,8 for nodular cast iron*

B : *equal to:*
- *2 for steel*
- *2,3 for cast steel*
- *3,5 for nodular cast iron*

d) *Burst test*

1) *Pressure retaining parts not requiring fatigue analysis and fracture mechanics analysis may be accepted on the basis of a certified burst test at the discretion of the Society and the detailed stress analysis required by [7.3.3], item b), need not be provided.*

2) *The minimum bursting pressure is to be calculated as follows:*

$$P_b = P \cdot A \cdot \frac{\sigma_{Ba}}{\sigma_B}$$

where:

P_b : *Minimum bursting pressure*

P : *Design pressure as defined in [7.3.3], item a)*

A : *as from [7.3.3], item c)*

σ_{Ba} : *Actual tensile strength*

σ_B : *Tensile strength as defined in [7.3.3], item c).*

7.3.4 Construction details *(1/1/2012)*

a) *General*

The construction is to be such as to minimise the local concentration of stress.

b) *Welds*

1) *The welding details and welding procedures are to be approved.*
2) *All welded joints within the pressure boundary of a rudder actuator or connecting parts transmitting mechanical loads are to be full penetration type or of equivalent strength.*

c) *Oil seals*

1) *Oil seals between non-moving parts, forming part of the external pressure boundary, are to be of the metal upon metal type or of an equivalent type.*
2) *Oil seals between moving parts, forming part of the external pressure boundary, are to be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage may be accepted at the discretion of the Society.*

d) *Isolating valves*

Isolating valves are to be fitted at the connection of pipes to the actuator, and are to be directly mounted on the actuator.

e) *Relief valves*

Relief valves for protecting the rudder actuator against overpressure as required in Pt C, Ch 1, Sec 11, [2.2.5] are to comply with the following:

1) *the setting pressure is not to be less than 1,25 times the maximum working pressure expected under operating conditions required in Pt C, Ch 1, Sec 11, [3.3.1], item b),*
2) *the minimum discharge capacity of the relief valves is not to be less than the total capacity of all pumps which provide power for the actuator, increased by 10 per cent. Under such conditions, the rise in pressure is not to exceed 10 per cent of the setting pressure. In this regard, due consideration is to be given to extreme foreseen ambient conditions in respect of oil viscosity.*

7.3.5 Inspection and testing *(1/1/2012)*

a) *Non-destructive testing*

The rudder actuator is to be subjected to suitable and complete non-destructive testing to detect both surface flaws and volumetric flaws. The procedure and acceptance criteria for non-destructive testing is to be in accordance with requirements of recognised standards. If found necessary, fracture mechanics analysis may be used for determining maximum allowable flaw size.

b) *Other testing*

1) *Tests, including hydrostatic tests, of all pressure parts at 1,5 times the design pressure are to be carried out.*
2) *When installed on board the ship, the rudder actuator is to be subjected to a hydrostatic test and a running test.*

8 Additional requirements for asphalt tankers

8.1 Application

8.1.1 *(1/1/2012)*

The provisions of this Article apply, in addition to those contained in Articles [1] to [7] above, to oil tankers having the additional service notation **asphalt carrier**.

8.2 Additional requirements

8.2.1 Heating systems *(1/1/2012)*

a) Cargo tanks intended for the carriage of asphalt solutions are to be equipped with a heating system capable of preserving the asphalt solutions in their liquid state. Valves are to be fitted on the heating system inlet and outlet.

b) Cargo piping and associated fittings outside tanks are to be provided with suitable heating devices. For heating of piping and fittings, refer to Sec 4, [2.6].

8.2.2 Thermometers *(1/1/2012)*

Each tank is to be equipped with at least two thermometers in order to ascertain the temperature of the asphalt solution.

8.2.3 Insulation *(1/1/2012)*

Cargo piping and associated fittings outside tanks are to be suitably insulated, where necessary.

9 Specific requirements for FLS tanker

9.1 Application

9.1.1 *(1/1/2012)*

The provisions of this Article, derived from Annex II of the MARPOL 73/78 Convention, are related to the prevention of pollution by noxious liquid substances. They apply as follows:

a) Where the ship is granted only the service notation **FLS tanker**, these provisions replace those of [5] related to the prevention of pollution by cargo oil.

b) Where the ship is granted both service notations **oil tanker**, **flashpoint > 60°C** and **FLS tanker**, **flashpoint > 60°C** , these provisions are additional to those of [5].

9.2 Design requirements

9.2.1 General *(1/1/2012)*

The requirements of [9.2] apply to ships carrying category Z substances (see App 4, Tab 1).

9.2.2 Cargo piping and pumping system *(1/1/2012)*

The pumping and piping arrangement is to ensure that each tank does not retain a quantity of residue in excess of 75 litres in the tank and its associated piping. A performance test shall be carried out in accordance with Appendix 5 of Annex II of MARPOL 73/78 Convention as amended

9.2.3 Underwater discharge *(1/1/2012)*

An underwater discharge outlet (or outlets) shall be fitted.

The underwater discharge outlet (or outlets) shall be located within the cargo area in the vicinity of the turn of the bilge and shall be so arranged as to avoid the re-intake of residue/water mixtures by the ship's seawater intakes.

The underwater discharge outlet arrangement is to be such that the residue/water mixture discharged into the sea will not pass through the ship's boundary layer. To this end, when the discharge is made normal to the ship's shell plating, the minimum diameter of the discharge outlet is governed by the following equation:

$$d = \frac{Q_d}{5L_d}$$

where:

d : Minimum diameter of the discharge outlet (m)

L_d : Distance from the forward perpendicular to the discharge outlet (m)

Q_d : The maximum rate selected at which the ship may discharge a residue/water mixture through the outlet (m^3/h).

When the discharge is directed at an angle to the ship's shell plating, the above relationship is to be modified by substituting for Q_d the component of Q_d which is normal to the ship's shell plating.

9.2.4 Ventilation equipment *(1/1/2012)*

a) If residues from cargo tanks are removed by means of ventilation, ventilation equipment meeting the following provisions is to be provided.

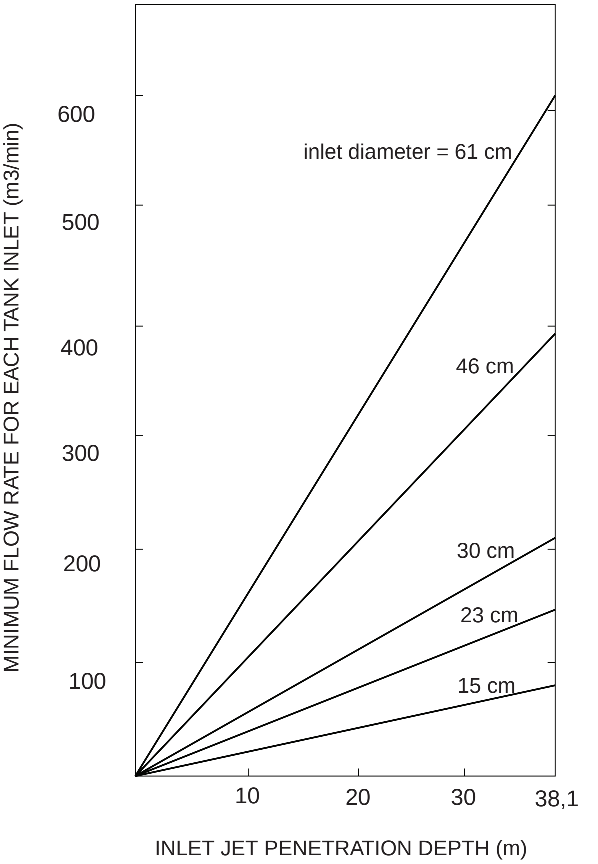
Note 1: Ventilation procedures may be applied only to those substances having a vapour pressure greater than 5.10^3 Pa at 20°C.

b) The ventilation equipment is to be capable of producing an air jet which can reach the tank bottom. Fig 2 may be used to evaluate the adequacy of ventilation equipment used for ventilating a tank of given depth.

c) The ventilation equipment is to be placed in the tank opening closest to the tank sump or suction point.

d) When practicable, the ventilation equipment is to be positioned so that the air jet is directed at the tank sump or suction point and impingement of the air jet on tank structural members is to be avoided as far as possible.

Figure 2 : Minimum flow rate as a function of jet penetration depth *(1/1/2012)*



Note: Jet penetration depth is to be compared against tank height.

SECTION 6 ELECTRICAL INSTALLATIONS

1 General

1.1 Application

1.1.1 *(1/4/2006)*

The requirements in this Section apply, in addition to those contained in Part C, Chapter 2, to ships with the service notations **oil tanker ESP** or **oil tanker ESP CSR** or **FLS tanker**.

1.2 Documentation to be submitted

1.2.1 In addition to the documentation requested in Pt C, Ch 2, Sec 1, Tab 1, the following are to be submitted for approval:

a) plan of hazardous areas

b) document giving details of types of cables and safety characteristics of the equipment installed in hazardous areas

c) diagrams of tank level indicator systems, high level alarm systems and overflow control systems where requested.

1.3 System of supply

1.3.1 *(1/1/2007)*

Earthed systems with hull return are not permitted, with the following exceptions to the satisfaction of the Society:

a) impressed current cathodic protective systems

b) limited and locally earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible resulting current does not flow directly through any hazardous area

c) insulation level monitoring devices, provided that the circulation current of the device does not exceed 30 mA under the most unfavourable conditions

d) intrinsically safe systems.

1.3.2 In insulated distribution systems, no current carrying part is to be earthed, other than:

a) through an insulation level monitoring device

b) through components used for the suppression of interference in radio circuits.

1.3.3 *(1/7/2009)*

The additional limitations in the choice of the system of supply (type of distribution system) as per SOLAS Ch.II-1 Reg. 45.4.3 apply to ships subject to the SOLAS Convention.

1.4 Electrical equipment

1.4.1 *(1/1/2007)*

Electrical equipment, cables and wiring are not to be installed in hazardous locations unless they conform with standards not inferior to those given in IEC 60092-502 Standard.

However, for locations not covered by such standards, electrical equipment, cables and wiring which do not conform to the standards may be installed in hazardous locations based on a risk assessment to the satisfaction of the Society, to ensure that an equivalent level of safety is assured.

1.5 Earth detection

1.5.1 *(1/1/2007)*

For both insulated and earthed distribution systems a device, or devices, are to be installed to continuously monitor the insulation to earth and to give an audible and visual alarm at a manned position in the event of an abnormally low level of insulation resistance and/or high level of leakage current.

The above is not applicable to systems mentioned in [1.3.1].

1.6 Precautions against inlet of gases or vapours

1.6.1 Suitable arrangements are to be provided, to the satisfaction of the Society, so as to prevent the possibility of gases or vapours passing from a gas-dangerous space to another space through runs of cables or their conduits.

1.7 Electrical equipment permitted in hazardous areas

1.7.1 *(1/1/2007)*

Electrical equipment permitted in hazardous areas is that indicated in Pt C, Ch 2, Sec 3, [10.1.4], Pt C, Ch 2, Sec 3, [10.1.5], and Pt C, Ch 2, Sec 3, [10.1.6].

1.7.2 *(1/1/2007)*

In addition to the requirements of [1.7.1], in Zone 1 and Zone 2 the installation of the following is permitted:

hull fittings containing the terminals or shell plating penetrations for anodes or electrodes of animpressed current cathodic protection system, or transducers such as those for depth sounding or log systems, provided that such fittings are of gas-tight construction or housed within a gas-tight enclosure, and are not located adjacent to a cargo tank bulkhead. The design of such fittings or their enclosures and the means by which cables enter, as well as any testing to establish their gas-tightness, are to be to the satisfaction of the Society. The associated cables are to be protected by means of heavy gauge steel pipes with gas-tight joints.

1.7.3 The explosion group and temperature class of electrical equipment of a certified safe type are to be at least IIA and T3 in the case of ships arranged for the carriage of crude oil or other petroleum products.

Other characteristics may be required for dangerous products other than those above.

1.7.4 Enclosed or semi-enclosed spaces (not containing a source of hazard) having a direct opening, including those for ventilation, into any hazardous area, are to be designated as the same hazardous zone as the area in which the opening is located.

Electrical installations are to comply with the requirements for the space or area into which the opening leads.

Note 1: For openings, access and ventilation conditions affecting the extent of hazardous areas, see IEC Standard 60092-502.

2 Special requirements for oil tankers carrying flammable liquids having a flash point not exceeding 60°C

2.1 Hazardous area classification

2.1.1 *(1/1/2007)*

For hazardous area classification see Tab 1.

3 Special requirements for oil tankers carrying flammable liquids having a flash point exceeding 60°C

3.1 Hazardous area classification

3.1.1 *(1/1/2007)*

For hazardous area classification see Tab 2.

3.2 Cargoes heated to a temperature above their flash point and cargoes heated to a temperature within 15°C of their flash point

3.2.1 *(1/1/2007)*

The requirements under [2] apply.

4 Special requirements for FLS tankers

4.1 General, hazardous locations and types of equipment

4.1.1 The requirements under Ch 8, Sec 10 apply.

Table 1 : Classification of hazardous areas for oil tankers carrying flammable liquids having a flash point not exceeding 60°C *(1/7/2012)*

Spaces		Hazardous area
N.	Description	
1	Interior of cargo tanks, slop tanks, any pipework of pressure relief or other venting systems for cargo and slop tanks, pipes and equipment containing cargo or developing flammable gases or vapours.	Zone 0
2	Void spaces adjacent to, above or below integral cargo tanks.	Zone 1
3	Hold spaces containing independent cargo tanks.	Zone 1
4	Cofferdams and permanent (for example, segregated) ballast tanks adjacent to cargo tanks.	Zone 1
5	Cargo pump rooms.	Zone 1
6	Enclosed or semi-enclosed spaces immediately above cargo tanks (e.g. 'tweendecks) or having bulkheads above and in line with cargo tank bulkheads, unless protected by a diagonal plate acceptable to the Society.	Zone 1
7	Spaces other than cofferdams, adjacent to and below the top of a cargo tank (e.g. trunks, passageways and holds) as well as double bottoms and pipe tunnels below cargo tanks.	Zone 1
8	Areas on open deck, or semi-enclosed spaces on open deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo manifold valve, cargo valve, cargo pipe flange, cargo pump room ventilation outlets and cargo tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation.	Zone 1
9	Areas on open deck, or semi-enclosed spaces on open deck above and in the vicinity of any cargo gas outlet intended for the passage of large volumes of gas or vapour mixture during cargo loading and ballasting or during discharging, within a vertical cylinder of unlimited height and 6m radius centred upon the centre of the outlet, and within a hemisphere of 6m radius below the outlet.	Zone 1
10	Areas on open deck, or semi-enclosed spaces on open deck, within 1,5m of cargo pump room entrances, cargo pump room ventilation inlets, openings into cofferdams or other Zone 1 spaces.	Zone 1
11	Areas on open deck within spillage coamings surrounding cargo manifold valves and 3 m beyond these, up to a height of 2,4 m above the deck.	Zone 1
12	Areas on open deck over all cargo tanks (including all ballast tanks within the cargo tank area) where structures are restricting the natural ventilation and to the full breadth of the ship plus 3m fore and aft of the forward-most and aft-most cargo tank bulkhead, up to a height of 2,4m above the deck.	Zone 1
13	Compartments for cargo hoses.	Zone 1
14	Enclosed or semi-enclosed spaces in which pipes containing cargoes are located.	Zone 1
15	Areas 2m beyond the area defined in item 8.	Zone 2
16	Areas of 1,5 m surrounding open or semi-enclosed spaces of Zone 1.	Zone 2
17	Areas 4m beyond the cylinder and 4m beyond the sphere defined in item 9.	Zone 2
18	Areas on open deck extending to the coamings fitted to keep any spills on deck and away from the accommodation and service areas and 3m beyond these up to a height of 2,4m above the deck.	Zone 2
19	Areas on open deck over all cargo tanks (including all ballast tanks within the cargo tank area) where unrestricted natural ventilation is guaranteed and to the full breadth of the ship plus 3m fore and aft of the forward-most and aft-most cargo tank bulkhead, up to a height of 2,4m above the deck surrounding open or semi-enclosed spaces of Zone 1.	Zone 2
20	Spaces forward of the open deck areas to which reference is made in item 12 and item 18, below the level of the main deck, and having an opening on the main deck or at a level less than 0,5m above the main deck, unless: a) the entrances to such spaces do not face the cargo tank area and, together with all other openings to the spaces, including ventilation system inlets and exhausts, are situated at least 5m from the foremost cargo tank and at least 10m measured horizontally from any cargo tank outlet or gas or vapour outlet; and b) the spaces are mechanically ventilated.	Zone 2

Table 2 : Hazardous areas classification for oil tankers carrying flammable liquids having a flash point exceeding 60°C unheated or heated to a temperature below and not within 15°C of their flash point

Spaces		Hazardous area
No.	Description	
1	Interior of cargo tanks, slop tanks, any pipework of pressure relief or other venting systems for cargo and slop tanks, pipes and equipment containing cargo.	Zone 2

APPENDIX 1 DEVICES TO PREVENT THE PASSAGE OF FLAME INTO THE CARGO TANKS

1 General

1.1 Application

1.1.1 *(1/4/2006)*

This Appendix is intended to cover the design, testing, location and maintenance of "devices to prevent the passage of flame into cargo tanks" (hereafter called "devices") of ships having the service notations **oil tanker ESP, oil tanker ESP CSR** or **combination carrier** carrying crude oil, petroleum products having a flashpoint of 60°C (closed cup test) or less and a Reid vapour pressure below atmospheric pressure, and other liquids with similar fire hazard. It also applies to ships having the service notation **FLS tanker** carrying flammable products having such a flashpoint.

1.1.2 *(1/4/2006)*

Ships having the service notations **oil tanker ESP**, **oil tanker ESP CSR**, **combination carrier** or **FLS tanker** and fitted with an inert gas system in accordance with Pt C, Ch 4, Sec 1, [9] are to be fitted with devices which comply with this Appendix, except that the tests specified in [4.2.3] and [4.3.3] are not required. Such devices are only to be fitted at openings unless they are tested in accordance with [4.4].

1.1.3 This Appendix is intended for devices protecting cargo tanks containing crude oil, petroleum products and flammable chemicals. In the case of the carriage of chemicals, the test media referred to in [4] can be used. However, devices for chemical tankers dedicated to the carriage of products with MESG less than 0,9 mm are to be tested with appropriate media.

Note 1: For MESG (Maximum Experimental Safe Gap) reference should be made to IEC - publication 79-1.

1.1.4 Devices are to be tested and located in accordance with this Appendix.

1.1.5 Devices are installed to protect:

a) openings designed to relieve pressure or vacuum caused by thermal variations (see Sec 4, [4.2.2], item a));

b) openings designed to relieve pressure or vacuum during cargo loading, ballasting or discharging (see Sec 4, [4.2.2], item b));

c) outlets designed for gas-freeing (see Sec 4, [4.3.3]).

1.1.6 Devices are not to be capable of being bypassed or blocked open unless they are tested in the bypassed or blocked open position in accordance with [4].

1.1.7 This Appendix does not include consideration of sources of ignition such as lightning discharges, since insufficient information is available to formulate equipment recommendations. All cargo handling, tank cleaning and ballasting operations are to be suspended on the approach of an electrical storm.

1.1.8 This Appendix is not intended to deal with the possibility of the passage of flame from one cargo tank to another on tankers with common venting systems.

1.1.9 When outlet openings of gas-freeing systems on tankers not fitted with inert gas systems are required to be protected with devices, they are to comply with this Appendix except that the tests specified in [4.2.3] and [4.3.3] are not required.

1.1.10 Certain of the tests prescribed in [4] of this Appendix are potentially hazardous, but no attempt is made in this Appendix to specify safety requirements for these tests.

1.2 Definitions

1.2.1 Premise

For the purpose of this Appendix, the definitions given in the following paragraphs are applicable.

1.2.2 Flame arrester

A flame arrester is a device to prevent the passage of flame in accordance with a specified performance standard. Its flame arresting element is based on the principle of quenching.

1.2.3 Flame screen

A flame screen is a device utilising wire mesh to prevent the passage of unconfined flames in accordance with a specified performance standard.

1.2.4 Flame speed

The flame speed is the speed at which a flame propagates along a pipe or other system.

1.2.5 Flashback

Flashback is the transmission of a flame through a device.

1.2.6 High velocity vent

A high velocity vent is a device to prevent the passage of flame consisting of a mechanical valve which adjusts the opening available for flow in accordance with the pressure at the inlet of the valve in such a way that the efflux velocity cannot be less than 30 m/s.

1.2.7 Pressure/vacuum valve

A pressure/vacuum valve is a device designed to maintain pressure and vacuum in a closed container within preset limits.

Note 1: Pressure/vacuum valves are devices to prevent the passage of flame when designed and tested in accordance with this Appendix.

1.3 Instruction manual

1.3.1 The manufacturer is to supply a copy of the instruction manual, which is to be kept on board the tanker and which is to include:

a) installation instructions

b) operating instructions

c) maintenance requirements, including cleaning (see [2.3.3])

d) a copy of the laboratory report referred to in [4.6]

e) flow test data, including flow rates under both positive and negative pressures, operating sensitivity, flow resistance and velocity.

2 Design of the devices

2.1 Principles

2.1.1 Depending on their service and location, devices are required to protect against the propagation of:

a) moving flames, and/or

b) stationary flames from pre-mixed gases after ignition of gases resulting from any cause.

2.1.2 When flammable gases from outlets ignite, the following four situations may occur:

a) at low gas velocities the flame may:
   1) flashback, or
   2) stabilise itself as if the outlet were a burner.

b) at high gas velocities, the flame may:
   1) burn at a distance above the outlet, or
   2) be blown out.

2.1.3 In order to prevent the passage of flame into a cargo tank, devices are to be capable of performing one or more of the following functions:

a) permitting the gas to pass through passages without flashback and without ignition of the gases on the protected side when the device is subjected to heating for a specified period;

b) maintaining an efflux velocity in excess of the flame speed for the gas irrespective of the geometric configuration of the device and without the ignition of gases on the protected side, when the device is subjected to heating for a specified period; and

c) preventing an influx of flame when conditions of vacuum occur within the cargo tanks.

2.2 Mechanical design

2.2.1 The casing or housing of devices is to meet similar standards of strength, heat resistance and corrosion resistance as the pipe to which it is attached.

2.2.2 The design of devices is to allow for ease of inspection and removal of internal elements for replacement, cleaning or repair.

2.2.3 All flat joints of the housing are to be machined true and are to provide an adequate metal-to-metal contact.

2.2.4 Flame arrester elements are to fit in the housing in such a way that flame cannot pass between the element and the housing.

2.2.5 Resilient seals may be installed only if their design is such that if the seals are partially or completely damaged or burned, the device is still capable of effectively preventing the passage of flame.

2.2.6 Devices are to allow for efficient drainage of moisture without impairing their efficiency to prevent the passage of flame.

2.2.7 The casing, flame arrester element and gasket materials are to be capable of withstanding the highest pressure and temperature to which the device may be exposed under both normal and specified fire test conditions.

2.2.8 End-of-line devices are to be so constructed as to direct the efflux vertically upwards.

2.2.9 Fastenings essential to the operation of the device, i.e. screws, etc., are to be protected against loosening.

2.2.10 Means are to be provided to check that any valve lifts easily without remaining in the open position.

2.2.11 Devices in which the flame arresting effect is achieved by the valve function and which are not equipped with flame arrester elements (e.g. high velocity valves) are to have a width of the contact area of the valve seat of at least 5 mm.

2.2.12 Devices are to be resistant to corrosion in accordance with [4.5.1].

2.2.13 Elements, gaskets and seals are to be of material resistant to both seawater and the cargoes carried.

2.2.14 The casing of the housing is to be capable of passing a hydrostatic pressure test, as required in [4.5.2].

2.2.15 In-line devices are to be able to withstand without damage or permanent deformation the internal pressure resulting from detonation when tested in accordance with [4.4].

2.2.16 A flame arrester element is to be designed to ensure quality control of manufacture to meet the characteristics of the prototype tested, in accordance with this Appendix.

2.3 Performance

2.3.1 Devices are to be tested in accordance with [4.5] and thereafter shown to meet the test requirements of [4.2] to [4.4], as appropriate.

Note 1: End-of-line devices which are intended for exclusive use at openings of inerted cargo tanks need not be tested against endurance burning as specified in [4.2.3].

Note 2: Where end-of-line devices are fitted with cowls, weather hoods and deflectors, etc., these attachments are to be fitted for the tests described in [4.2].

Note 3: When venting to atmosphere is not performed through an end-of-line device according to Note 2, or a detonation flame arrester according to [3.2.2], the in-line device is to be specifically tested with the inclusion of all pipes, tees, bends, cowls, weather hoods, etc., which may be fitted between the device and atmosphere. The testing is to consist of the flashback test in [4.2.2] and, if for the given installation it is possible for a stationary flame to rest on the device, the testing is also to include the endurance burning test in [4.2.3].

2.3.2 Performance characteristics such as the flow rates under both positive and negative pressure, operating sensitivity, flow resistance and velocity are to be demonstrated by appropriate tests.

2.3.3 Devices are to be designed and constructed to minimise the effect of fouling under normal operating conditions. Instructions on how to determine when cleaning is required and the method of cleaning are to be provided for each device in the manufacturer's instruction manual.

2.3.4 Devices are to be capable of operating in freezing conditions and if any device is provided with heating arrangements so that its surface temperature exceeds 85°C, then it is to be tested at the highest operating temperature.

2.3.5 Devices based upon maintaining a minimum velocity are to be capable of opening in such a way that a velocity of 30 m/s is immediately initiated, maintaining an efflux velocity of at least 30 m/s at all flow rates and, when the gas flow is interrupted, closing in such a way that this minimum velocity is maintained until the valve is fully closed.

2.3.6 In the case of high velocity vents, the possibility of inadvertent detrimental hammering leading to damage and/or failure is to be considered, with a view to eliminating it.

Note 1: Hammering is intended to mean a rapid full stroke opening/closing, not foreseen by the manufacturer during normal operations.

2.4 Flame screens

2.4.1 Flame screens are to be:

a) designed in such a manner that they cannot be inserted improperly in the opening
b) securely fitted in openings so that flames cannot circumvent the screen
c) able to meet the requirements of this Appendix. For flame screens fitted at vacuum inlets through which vapours cannot be vented, the test specified in [4.2.3] need not be complied with.
d) protected against mechanical damage.

2.5 Marking of devices

2.5.1 Each device is to be permanently marked, or have a permanently fixed tag made of stainless steel or other corrosion-resistant material, to indicate:

a) the manufacturer's name or trade mark
b) the style, type, model or other manufacturer's designation for the device
c) the size of the outlet for which the device is approved
d) the approved location for installation, including maximum or minimum length of pipe, if any, between the device and the atmosphere
e) the direction of flow through the device
f) the test laboratory and report number, and
g) compliance with the requirements of this Appendix.

3 Sizing, location and installation of devices

3.1 Sizing of devices

3.1.1 To determine the size of devices to avoid inadmissible pressure or vacuum in cargo tanks during loading or discharging, calculations of pressure losses are to be carried out.

The following parameters are to be taken into account:

a) loading/discharge rates
b) gas evolution
c) pressure loss through devices, taking into account the resistance coefficient
d) pressure loss in the vent piping system
e) pressure at which the vent opens if a high velocity valve is used
f) density of the saturated vapour/air mixture
g) possible fouling of a flame arrester; 70% of its rated performance is to be used in the pressure drop calculation of the installation.

3.2 Location and installation of devices

3.2.1 General

a) Devices are to be located at the vent outlets to atmosphere unless tested and approved for in-line installation.
b) Devices for in-line installation may not be fitted at the outlets to atmosphere unless they have also been tested and approved for that position.

3.2.2 Detonation flame arresters

Where detonation flame arresters are installed as in-line devices venting to atmosphere, they are be located at a sufficient distance from the open end of the pipeline so as to preclude the possibility of a stationary flame resting on the arrester.

3.2.3 Access to the devices

Means are to be provided to enable personnel to reach devices situated more than 2 m above deck to facilitate maintenance, repair and inspection.

4 Type test procedures

4.1 Principles

4.1.1 Tests are to be conducted by a laboratory acceptable to the Society.

4.1.2 Each size of each model is to be submitted for type testing. However, for flame arresters, testing may be limited to the smallest and the largest sizes and one additional size in between to be chosen by the Society. Devices are to have the same dimensions and most unfavourable clearances expected in the production model. If a test device is modified during the test program, the testing is to be restarted.

4.1.3 Tests described in this Article using gasoline vapours (a non-leaded petroleum distillate consisting essentially of aliphatic hydrocarbon compounds with a boiling range approximating 65°C - 75°C), technical hexane vapours or technical propane, as appropriate, are suitable for all devices protecting tanks containing a flammable atmosphere of the cargoes referred to in Sec 1, [1.1.1]. This does not preclude the use of gasoline vapours or technical hexane vapours for all tests referred to in this Article.

4.1.4 After the relevant tests, the device is not to show mechanical damage that affects its original performance.

4.1.5 Before the tests the following equipment, as appropriate, is to be properly calibrated:

a) gas concentration meters

b) thermometers

c) flow meters

d) pressure meters, and

e) time recording devices.

4.1.6 The following characteristics are to be recorded, as appropriate, throughout the tests:

a) concentration of fuel in the gas mixture

b) temperature of the test gas mixture at inflow of the device, and

c) flow rates of the test gas mixtures when applicable.

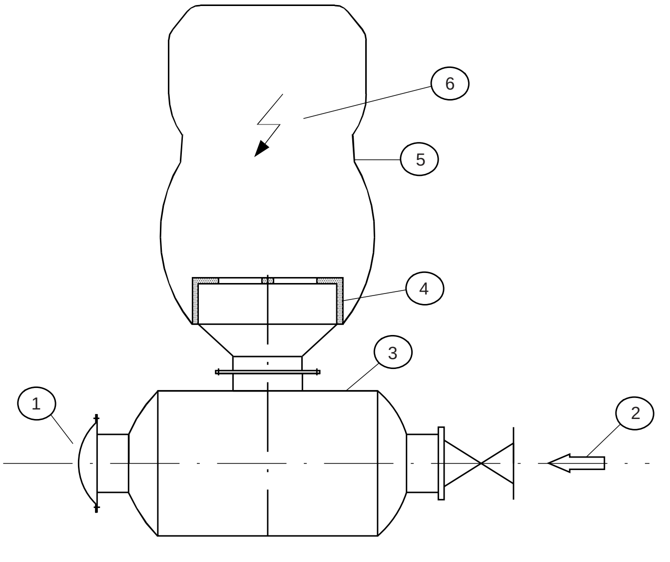
4.1.7 Flame passage is to be observed by recording, e.g. temperature, pressure, or light emission, by suitable sensors on the protected side of the device; alternatively, flame passage may be recorded on video tape.

4.2 Test procedure for flame arresters located at openings to the atmosphere

4.2.1 Test rig

The test rig is to consist of an apparatus producing an explosive mixture, a small tank with a diaphragm, a flanged prototype of the flame arrester, a plastic bag and a firing source in three positions (see Fig 1). Other test rigs may be used, provided the tests referred to in this Article are carried out to the satisfaction of the Society.

Figure 1 : Test rig for flashback test



(1): Plastic bursting diaphragm

(2): Explosive mixture inlet

(3): Tank

(4): Flame arresting device

(5): Plastic bag

(6): Ignition source

Note 1: The dimensions of the plastic bag are dependent on those of the flame arrester, but for flame arresters normally used on tankers the plastic bag may have a circumference of 2 m, a length of 2,5 m and a wall thickness of 0,05 mm.

Note 2: In order to avoid remnants of the plastic bag from falling back on to the device being tested after ignition of the fuel/air mixture, it may be useful to mount a coarse wire frame across the device within the plastic bag. The frame is to be so constructed as not to interfere with the test result.

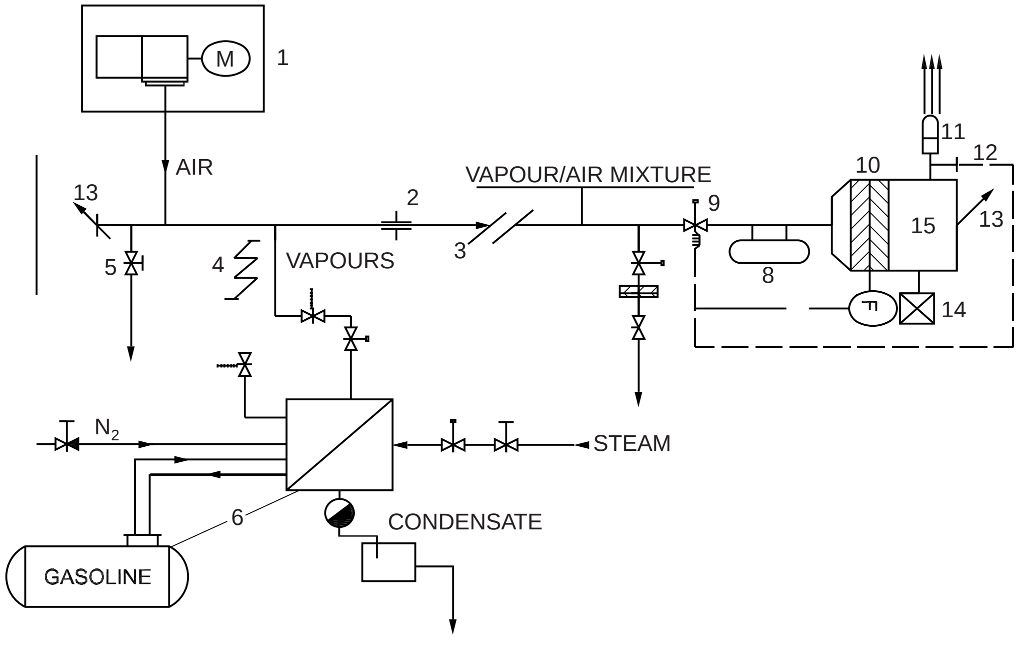
4.2.2 Flashback test

A flashback test is to be carried out as follows:

a) The tank, flame arrester assembly and the plastic bag (see [4.2.1]) enveloping the prototype flame arrester are to be filled so that this volume contains the most easily ignitable propane/air mixture (see IEC Publication 79/1). The concentration of the mixture is to be verified by appropriate testing of the gas composition in the plastic bag. Where devices referred to in [2.3.1], Note 3 are tested, the plastic bag is to be fitted at the outlet to atmosphere. Three ignition sources are to be installed along the axis of the bag, one close to the flame arrester, another as far away as possible therefrom, and the third at the mid-point between these two. These three sources are to be fired in succession, twice in each of the three positions. The temperature of the test gas is to be within the range of 15°C to 40°C.

b) If a flashback occurs, the tank diaphragm will burst and this will be audible and visible to the operator by the emission of a flame. Flame, heat and pressure sensors may be used as an alternative to a bursting diaphragm.

Figure 2 : Schematic Plan of the Test Plant for High Velocity Valves (endurance burning test only)



(1): Fan with variable speed

(2): Volume rate indicator

(3): Pipe (diameter=500 mm, length=30 m)

(4): Heated vapour pipe

(5): Air bypass

(6): Evaporator and gasoline storage tank

(7): Vapour/air mixture bypass

(8): Extinguishing agents

(9): Automatic control and quick action stop valve

(10): Explosion arresting crimped ribbon with temperature sensors for the safety of the test rig

(11): High velocity valve to be tested

(12): Flame detector

(13): Bursting diaphragm

(14): Concentration indicator

(15): Tank

4.2.3 Endurance burning test

An endurance burning test is to be carried out, in addition to the flashback test, for flame arresters at outlets where flows of explosive vapour are foreseeable:

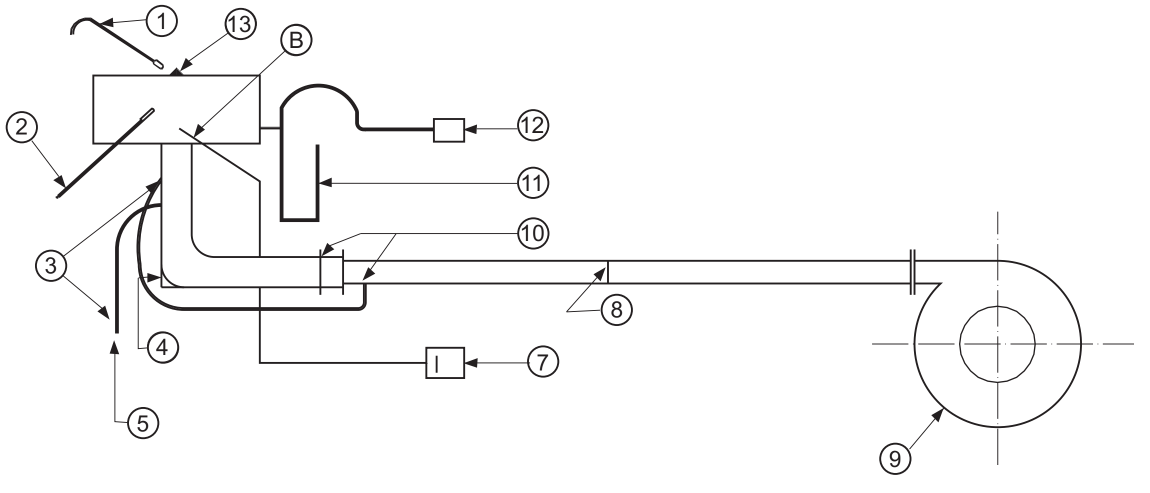
a) The test rig as referred to in [4.2.1] may be used, without the plastic bag. The flame arrester is to be so installed that the mixture emission is vertical. In this position the mixture is to be ignited. Where devices referred to in [2.3.1] Note 3, are tested, the flame arrester is to be so installed as to reflect its final orientation.

b) Endurance burning is to be achieved by using the most easily ignitable gasoline vapour/air mixture or the most easily ignitable technical hexane vapour/air mixture with the aid of a continuously operated pilot flame or a continuously operated spark igniter at the outlet. The test gas is be introduced upstream of the tank shown in Fig 1. Maintaining the concentration of the mixture as specified above, by varying the flow rate, the flame arrester is to be heated until the highest obtainable temperature on the cargo tank side of the arrester is reached. Temperatures are to be measured, for example, at the protected side of the flame quenching matrix of the arrester (or at the seat of the valve in the case of testing high velocity vents according to [4.3]). The highest obtainable temperature may be considered to have been reached when the rate of rise of temperature does not exceed 0,5°C per minute over a ten-minute period. This temperature is to be maintained for a period of ten minutes, after which the flow is to be stopped and the conditions observed. The temperature of the test gas is to be within the range of 15°C to 40°C.

If no temperature rise occurs at all, the arrester is to be inspected for a more adequate position of the temperature sensor, taking account of the visually registered position of the stabilised flame during the first test sequence. Positions which require the drilling of small holes into fixed parts of the arrester are to be taken into account. If all this is not successful, the temperature sensor is to be affixed at the unprotected side of the arrester in a position near to the stabilised flame.

If difficulties arise in establishing stationary temperature conditions (at elevated temperatures), the following criterion is to apply: using the flow rate which produced the maximum temperature during the foregoing test sequence, endurance burning is to be continued for a period of two hours from the time the above-mentioned flow rate has been established. After that period the flow is to be stopped and the conditions observed. Flashback is not to occur during this test.

Figure 3 : Test Rig for High Velocity Vents



(1): Primary igniter

(2): Secondary igniter

(3): Cocks

(4): Explosion door

(5): Gas supply

(6): Flashback detector

(7): Chart recorder

(8): Flow meter

(9): Fan

(10): Spade blank and bypass line for low rates

(11): Pressure gauge

(12): Gas analyser

(13): High velocity vent to be tested

4.2.4 Pressure/vacuum valve integrated to a flame arresting device

When a pressure/vacuum valve is integrated to a flame arresting device, the flashback test is to be performed with the pressure/ vacuum valve blocked open. If there are no additional flame quenching elements integrated in a pressure valve, this valve is to be considered and tested as a high velocity vent valve according to [4.3].

4.3 Test procedures for high velocity vents

4.3.1 Test rig

The test rig is to be capable of producing the required volume flow rate. In Fig 2 and Fig 3 drawings of suitable test rigs are shown. Other test rigs may be used provided the tests are performed to the satisfaction of the Society.

4.3.2 Flow condition test

A flow condition test is to be carried out with high velocity vents using compressed air or gas at agreed flow rates. The following are to be recorded:

a) the flow rate; where air or a gas other than vapours of cargoes with which the vent is to be used is employed in the test, the flow rates achieved are to be corrected to reflect the vapour density of such cargoes

b) the pressure before the vent opens; the pressure in the test tank on which the device is located is not to rise at a rate greater than 0,01 MPa/min

c) the pressure at which the vent opens

d) the pressure at which the vent closes

e) the efflux velocity at the outlet which is not to be less than 30 m/s at any time when the valve is open.

4.3.3 Fire safety tests

The following fire safety tests are to be conducted while adhering to [2.3.6] using a mixture of gasoline vapour and air or technical hexane vapour and air, which produces the most easily ignitable mixture at the point of ignition. This mixture is to be ignited with the aid of a permanent pilot flame or a spark igniter at the outlet.

a) Flashback tests in which propane may be used instead of gasoline or hexane are to be carried out with the vent in the upright position and then inclined at 10° from the vertical. For some vent designs further tests with the vent inclined in more than one direction may be necessary. In each of these tests the flow is to be reduced until the vent closes and the flame is extinguished, and each is to be carried out at least 50 times. The vacuum side of combined valves is to be tested in accordance with [4.2.2] with the vacuum valve maintained in the open position for the duration of this test, in order to verify the efficiency of the device which is to be fitted.

b) An endurance burning test, as described in [4.2.3], is to be carried out. Following this test, the main flame is to be extinguished and then, with the pilot flame burning or the spark igniter discharging, small quantities of the most easily ignitable mixture are to be allowed to escape for a period of ten minutes maintaining a pressure below the valve of 90% of the valve opening setting, during which time flashback is not to occur. For the purpose of this test the soft seals or seats are to be removed.

4.4 Test rig and test procedures for detonation flame arresters located in-line

4.4.1 A flame arrester is to be installed at one end of a pipe of suitable length and of the same diameter as the flange of the flame arrester. On the opposed flange a pipe of a length corresponding to 10 pipe diameters is to be affixed and closed by a plastic bag or diaphragm. The pipe is to be filled with the most easily ignitable mixture of propane and air, which is then to be ignited. The velocity of the flame near the flame arrester is to be measured and is to have the same value as that for stable detonations.

Note 1: The dimensions of the plastic bag are to be at least 4 m circumference, 4 m length and a material wall thickness of 0,05 mm.

4.4.2 Three detonation tests are to be conducted, no flashback is to occur through the device and no part of the flame arrester is to be damaged or show permanent deformation.

4.4.3 Other test rigs may be used provided the tests are carried out to the satisfaction of the Society. A drawing of the test rig is shown in Fig 4.

4.5 Operational test procedure

4.5.1 Corrosion test

A corrosion test is to be carried out. In this test a complete device, including a section of the pipe to which it is fitted, is to be exposed to a 5% sodium chloride solution spray at a temperature of 25°C for a period of 240 hours, and allowed to dry for 48 hours. An equivalent test may be conducted to the satisfaction of the Society. Following this test, all movable parts are to operate properly and there are to be no corrosion deposits which cannot be washed off.

4.5.2 Hydraulic pressure test

A hydraulic pressure test is to be carried out in the casing or housing of a sample device, in accordance with [2.2.15].

4.6 Laboratory report

4.6.1 The laboratory report is to include:

a) detailed drawings of the device

b) types of tests conducted; where in-line devices are tested, this information is to include the maximum pressures and velocities observed in the test

c) specific advice on approved attachments

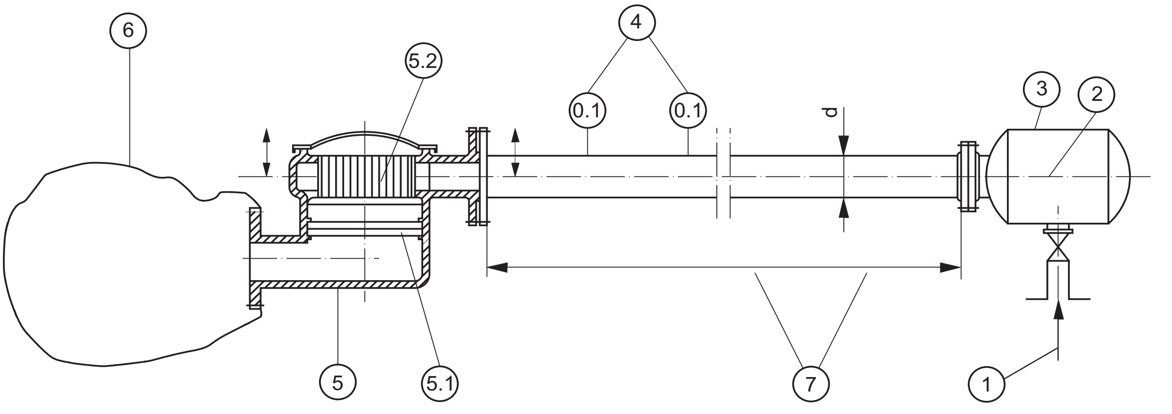
d) types of cargo for which the device is approved

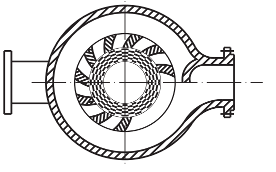
e) drawings of the test rig

f) in the case of high velocity vents, the pressures at which the device opens and closes and the efflux velocity, and

g) all the information marked on the device in [2.5].

Figure 4 : Test Rig for Arresters Located In-Line





SECTION A-A

(1): Explosive mixture inlet

(2): Ignition source; ignition within non-streaming mixture

(3): Tank

(4): Measuring system for flame speed of a stable detonation

(5): Flame arrester located in-line; (5.1): Flame arrester element; (5.2): Shock wave absorber

(6): Plastic bag

(7): l/d = 100

APPENDIX 2 DESIGN OF CRUDE OIL WASHING SYSTEMS

1 General

1.1 Application

1.1.1 *(1/4/2006)*

This Appendix applies to ships having the notation **oil tanker ESP** or **oil tanker ESP CSR** in the conditions stated in Sec 4, [4.6.1].

1.2 Definitions

1.2.1 Arrival ballast

For the purpose of this Appendix, "arrival ballast" means clean ballast as defined in Sec 1, [1.3.5].

1.2.2 Departure ballast

For the purpose of this Appendix, "departure ballast" means ballast other than arrival ballast.

1.3 Operations and Equipment Manual

1.3.1 The Operations and Equipment Manual of the crude oil washing system is to be submitted to the Society for information. It is to contain at least the following information:

a) line drawing of the crude oil washing system showing the respective position of pumps, lines and washing machines which relate to the crude oil washing system

b) a description of the system and a listing of procedures for checking that equipment is working properly during crude oil washing operations. This is to include a listing of the system and equipment parameters to be monitored, such as line pressure, oxygen level, machine revolutions, duration of cycles, etc. The established values for these parameters are to be included. The results of the tests carried out in accordance with [3.3] and the values of all parameters monitored during such tests are also to be included.

c) other information referred to in [2.1.8], [2.2.2], [2.3.2], [2.3.5], [2.4.3] and [3.3.1].

2 Design and installation

2.1 Piping

2.1.1 The crude oil washing pipes and all valves incorporated in the supply piping system are to be of steel or other equivalent material, of adequate strength having regard to the pressure to which they may be subjected, and properly jointed and supported.

Note 1: Grey cast iron may be permitted in the supply system for crude oil washing systems when complying with nationally approved standards.

2.1.2 The crude oil washing system is to consist of permanent pipework and is to be independent of the fire mains and of any system other than for tank washing except that sections of the ship's cargo system may be incorporated into the crude oil washing system provided that they meet the requirements applicable to crude oil pipework. Notwithstanding the above requirements, in combination carriers the following arrangements may be allowed:

a) the removal of the equipment, if necessary, when carrying cargoes other than crude oil, provided that, when reinstated, the system is as originally fitted and tested for oil-tightness

b) the use of flexible hose pipes to connect the crude oil washing system to tank washing machines if it is necessary to locate these machines in a cargo tank hatch cover. Such flexible hose pipes are to be provided with flanged connections, manufactured and tested in accordance with standards acceptable to the Society, and consistent with the duties the hoses are required to perform. The length of these hoses is not to be greater than necessary to connect the tank washing machines to an adjacent point just outside the hatch coaming. The hoses are to be removed to a suitably prepared and protected stowage location when not in use.

2.1.3 Provisions are to be made to prevent overpressure in the tank washing supply piping. Any relief device fitted to prevent overpressure is to discharge into the suction side of the supply pump. Alternative methods to the satisfaction of the Society may be accepted provided an equivalent degree of safety and environmental protection is provided.

Note 1: Where the system is served only by centrifugal pumps so designed that the pressure derived cannot exceed that for which the piping is designed, a temperature sensing device located in the pump casing is required to stop the pump in the case of overheating.

2.1.4 Where hydrant valves are fitted for water washing purposes on tank washing lines, all such valves are to be of adequate strength and provisions are to be made for such connections to be blanked off by blank flanges when washing lines may contain crude oil. Alternatively, hydrant valves are to be isolated from the crude oil washing system by spade blanks.

2.1.5 All connections for pressure gauges or other instrumentation are to be provided with isolating valves adjacent to the lines unless the fitting is of the sealed type.

2.1.6 No part of the crude oil washing system is to enter machinery spaces. Where the tank washing system is fitted with a steam heater for use when water washing, the heater is to be located outside machinery spaces and effectively isolated during crude oil washing by double shut-off valves or by clearly identifiable blanks.

2.1.7 Where combined crude oil-water washing supply piping is provided, the piping is to be so designed that it can be drained so far as practicable of crude oil, before water washing is commenced, into designated spaces. These spaces may be the slop tank or other cargo spaces.

2.1.8 The piping system is to be of such diameter that the greatest number of tank cleaning machines required, as specified in the Operations and Equipment Manual, can be operated simultaneously at the designed pressure and throughput. The arrangement of the piping is to be such that the required number of tank cleaning machines for each cargo compartment as specified in the Operations and Equipment Manual can be operated simultaneously.

2.1.9 The crude oil washing supply piping is to be anchored (firmly attached) to the ship's structure at appropriate locations, and means are to be provided to permit freedom of movement elsewhere to accommodate thermal expansion and flexing of the ship. The anchoring is to be such that any hydraulic shock can be absorbed without undue movement of the supply piping. The anchors are normally to be situated at the ends furthest from the entry of the crude oil supply to the supply piping. If tank washing machines are used to anchor the ends of branch pipes then special arrangements are necessary to anchor these sections when the machines are removed for any reason.

2.2 Tank washing machines

2.2.1 Tank washing machines for crude oil washing are to be permanently mounted and of a design acceptable to the Society.

2.2.2 The performance characteristic of a tank washing machine is governed by nozzle diameter, working pressure and the movement pattern and timing. Each tank cleaning machine fitted is to have a characteristic such that the sections of the cargo tank covered by that machine will be effectively cleaned within the time specified in the Operations and Equipment Manual.

2.2.3 Tank washing machines are to be mounted in each cargo tank and the method of support is to be to the satisfaction of the Society. Where a machine is positioned well below the deck level to cater for protuberances in the tank, consideration may need to be given to additional support for the machine and its supply piping.

2.2.4 Each machine is to be capable of being isolated by means of stop valves in the supply line. If a deck mounted tank washing machine is removed for any reason, provision is to be made to blank off the oil supply line to the machine for the period the machine is removed. Similarly, provision is to be made to close the tank opening with a plate or equivalent means.

Note 1: Where more than one submerged machine is connected to the same supply line, a single isolating stop valve in the supply line may be acceptable provided the rotation of the submerged machine can be verified in accordance with [2.2.10]

2.2.5 The number and location of tank washing machines are to be to the satisfaction of the Society.

2.2.6 The location of the machines is dependent upon the characteristics detailed in [2.2.2] and upon the configuration of the internal structure of the tank.

2.2.7 The number and location of the machines in each cargo tank are to be such that all horizontal and vertical areas are washed by direct impingement or effectively by deflection or splashing of the impinging jet. In assessing an acceptable degree of jet deflection and splashing, particular attention is to be paid to the washing of upward facing horizontal areas and the following parameters are to be used:

a) For horizontal areas of a tank bottom and the upper surfaces of a tank's stringers and other large primary structural members, the total area shielded from direct impingement by deck or bottom transverses, main girders, stringers or similar large primary structural members is not to exceed 10 per cent of the horizontal area of the tank bottom, the upper surface of stringers, and other large primary structural members.
b) For vertical areas of the sides of a tank, the total area of the tank's sides shielded from direct impingement by deck or bottom transverses, main girders, stringers or similar large primary structural members is not to exceed 15 per cent of the total area of the tank's sides.

In some installations, it may be necessary to consider the fitting of more than one type of tank washing machine in order to effect adequate coverage.

Note 1: With regard to the application of this requirement, a slop tank is considered as a cargo tank.

2.2.8 At the design stage the following minimum procedures are to be used to determine the area of the tank surface covered by direct impingement:

a) Using suitable structural plans, lines are set out from the tips of each machine to those parts of the tank within the range of the jets.
b) Where the configuration of the tanks is considered by the Society to be complicated, a pinpoint of light simulating the tip of the tank washing machine in a scale model of the tank is to be used.

2.2.9 The design of the deck mounted tank washing machines is to be such that means are provided external to cargo tanks which, when crude oil washing is in progress, would indicate the rotation and arc of the movement of the machine. Where the deck mounted machine is of the non-programmable, dual nozzle type, alternative methods to the satisfaction of the Society may be accepted provided an equivalent degree of verification is attained.

2.2.10 Where submerged machines are required, they are to be non-programmable and, in order to comply with the requirements of [2.2.7], it is to be possible to verify their rotation by one of the following methods:

a) by indicators external to the tanks
b) by checking the characteristic sound pattern of the machine, in which case the operation of the machine is to be verified towards the end of each wash cycle. Where two or more submerged machines are installed on the same supply line, valves are to be provided and arranged so that the operation of each machine can be

verified independently of other machines on the same supply line.

c) by gas freeing the tank and checking the operation of the machine with water during ballast voyages.

2.3 Pumps

2.3.1 Pumps supplying crude oil to tank cleaning machines are to be either the cargo pumps or pumps specifically provided for the purpose.

2.3.2 The capacity of the pumps is to be sufficient to provide the necessary throughput at the required pressure for the maximum number of tank cleaning machines required to be operated simultaneously as specified in the Operations and Equipment Manual. In addition to the above requirement, if an eductor system is fitted for tank stripping, the pumps are to be capable of supplying the eductor driving fluid to meet the provisions of [2.4.2].

2.3.3 The capacity of the pumps is to be such that the requirements of [2.3.2] can be met with any one pump inoperative. The pumping and piping arrangements are to be such that the crude oil washing system can be effectively operated with any one pump out of use.

2.3.4 The carriage of more than one grade of cargo is not to prevent crude oil washing of tanks.

2.3.5 To permit crude oil washing to be effectively carried out where the back pressure presented by the shore terminal is below the pressure required for crude oil washing, provision is to be made such that an adequate pressure to the washing machines can be maintained in accordance with [2.3.2]. This requirement is to be met with any one cargo pump out of action. The minimum supply pressure required for crude oil washing is to be specified in the Operations and Equipment Manual. Should this minimum supply pressure not be obtainable, crude oil washing operations are not to be carried out.

2.4 Stripping system

2.4.1 The design of the system for stripping crude oil from the bottom of every cargo tank is to be to the satisfaction of the Society.

2.4.2 The design and capacity of the tank stripping system are to be such that the bottom of the tank being cleaned is kept free of accumulations of oil and sediment towards completion of the tank washing process.

2.4.3 The stripping system is to be at least 1,25 times the total throughput of all the tank cleaning machines to be operated simultaneously when washing the bottom of the cargo tanks as described in the ship's Operations and Equipment Manual.

2.4.4 Means such as level gauges, hand dipping and stripping system performance gauges as referred to in [2.4.8] are to be provided for checking that the bottom of every cargo tank is dry after crude oil washing. Suitable arrangements for hand dipping are to be provided at the aftermost portion of a cargo tank and in three other suitable locations unless other approved means are fitted for efficiently ascertaining that the bottom of every cargo tank is dry. For the purpose of this paragraph, the cargo tank bottom is to be considered "dry" if there is no more than a small quantity of oil near the stripping suction with no accumulation of oil elsewhere in the tank.

2.4.5 Means are to be provided to drain all cargo pumps and lines at the completion of cargo discharge, where necessary, by connection to a stripping device. The line and pump draining is to be capable of being discharged both to a cargo tank and ashore. For discharge ashore, a special small diameter line is to be provided for this purpose and connected outboard of the ship's manifold valve. The cross-sectional area of this line is not to exceed 10 per cent of that of a main cargo discharge line.

Note 1: In crude oil tankers having individual cargo pumps in each tank, each pump having an individual piping system, dispensation from the required special small diameter line may be granted in cases where the combined amount of oil left in the tank after stripping and the volume of oil in the piping system from the manifold to the tank is less than 0,00085 times the volume of the cargo tank. The above consideration is also to apply if a deepwell cargo pump system is provided with an evacuating system for retained oil.

2.4.6 The means for stripping oil from cargo tanks are to be a positive displacement pump, self-priming centrifugal pump or eductor or other methods to the satisfaction of the Society. Where a stripping line is connected to a number of tanks, means are to be provided for isolating each tank not being stripped at that particular time.

2.4.7 The carriage of more than one grade of cargo is not to prevent crude oil washing of tanks.

2.4.8 Equipment is to be provided for monitoring the efficiency of the stripping system. All such equipment is to have remote read out facilities in the cargo control room or in some other safe and convenient place easily accessible to the officer in charge of cargo and crude oil washing operations. Where a stripping pump is provided, the monitoring equipment is to include either a flow indicator, or a stroke counter or revolution counter as appropriate, and pressure gauges at the inlet and discharge connections of the pump or equivalent. Where eductors are provided, the monitoring equipment is to include pressure gauges at the driving fluid intake and at the discharge and a pressure/vacuum gauge at the suction intake.

2.4.9 The internal structure of the tank is to be such that drainage of oil to the tank suctions of the stripping system is adequate to meet the requirements of [2.4.2] and [2.4.4].

2.5 Ballast lines

2.5.1 Where a separate ballast water system for ballasting cargo tanks is not provided, the arrangement is to be such that the cargo pump, manifolds and pipes used for ballasting can be safely and effectively drained of oil before ballasting.

3 Inspection and testing

3.1 Initial survey

3.1.1 The initial survey required in Sec 4, [6.3.2] is to include a complete inspection of the crude oil washing equipment and arrangements and, except for the cases specified in [3.3.3], an examination of the tanks after they have been crude oil washed and the additional checks specified in [3.3.1] and [3.3.2] to ensure that the washing system efficiency is in accordance with this Appendix.

3.2 Piping

3.2.1 The piping system is to be tested to one and a half times the working pressure after it has been installed on the ship.

3.3 Tank washing machines

3.3.1 To confirm the cleanliness of the tank and to verify the design in respect of the number and location of the tank washing machines, a visual inspection is to be made by entry to the tanks after a crude oil wash but prior to any water rinse which may be specified in the Operations and Equipment Manual. The bottom of the tank to be inspected may, however, be flushed with water and stripped in order to remove any wedge of liquid crude oil remaining on the tank bottom before gas freeing for entry. This inspection is to ensure that the tank is essentially free of oil clingage and deposits. If the flushing procedure is adopted, a similar but unflushed tank is to be used for the test specified in [3.3.2] below.

3.3.2 To verify the effectiveness of the stripping and drainage arrangements, a measurement is to be made of the amount of oil floating on top of the departure ballast. The ratio of the volume of oil on top of the departure ballast water to the volume of tanks that contain this water is not to exceed 0,00085. This test is to be carried out after crude oil washing and stripping in a tank similar in all relevant respects to the tank examined in accordance with [3.3.1] above, which has not been subjected to a water rinse or to the intervening water flushing permissible in [3.3.1] above.

3.3.3 When the Society is satisfied that ships are similar in all relevant respects, the provisions of [3.3.1] and [3.3.2] need only be applied to one such ship. Furthermore, where a ship has a series of tanks that are similar in all relevant respects then, for that series of tanks, the requirements of [3.3.1] need only be applied to one tank of that series.

3.4 Stripping system

3.4.1 Care is to be taken that both longitudinal and transverse drainage are satisfactory. Drainage is to be verified during the inspection required by [3.3].

APPENDIX 3 LIST OF OILS

1 Application

1.1 List of oils

1.1.1 *(1/7/2011)*

The list of oils given in Appendix 1 of Annex I of the MARPOL 73/78 Convention, except that naphtha solvent is, in the opinion of the Society, to be considered as a chemical to which Chapter 8 applies, includes the oils the carriage in bulk of which is covered by the service notations:

- **oil tanker**
- **oil tanker** ESP
- **oil tanker** ESP**, flash point >60°C**
- **oil tanker** ESP **CSR**
- **oil tanker** ESP **CSR, flash point >60°C**
- **asphalt tanker**
- **asphalt tanker** ESP.

under the provisions of Sec 1, [1.1.1].

APPENDIX 4 LIST OF "EASY CHEMICALS"

1 Application

1.1 Scope of the list of easy chemicals

1.1.1 The list set out in this Appendix includes all chemical products to which the IBC Code does not apply. Such products, referred to as "easy chemicals", are allowed to be carried by ships having the service notation **FLS tanker** or, where their flashpoint is above 60 °C, also by ships having the service notation **FLS tanker flash point > 60 °C**.

Where indicated in the list, some products are also allowed to be carried by ships having the service notation **tanker**.

1.2 Safety and pollution hazards

1.2.1 *(1/1/2009)*

a) *The following are products, which have been reviewed for their safety and pollution hazards and determined not to present hazards to such an extent as to warrant application of the* IBC *Code.*

b) *Although the products listed in this chapter fall outside the scope of the* IBC *Code, the attention is drawn to the fact that some safety precautions may be needed for their safe transportation. Accordingly, shall prescribe appropriate safety requirements.*

c) *Some liquid substances are identified as falling into Pollution Category Z and, therefore, subject to certain requirements of Annex II of MARPOL 73/78.*

d) *Liquid mixtures which are assessed or provisionally assessed under regulation 6.3 of MARPOL Annex II as falling into Pollution Category Z or OS, and which do not present safety hazards, may be carried under the appropriate entry in this Appendix for Noxious or Non-Noxious Liquid Substances, not otherwise specified (n.o.s.).*

e) The substances identified as falling into pollution category III are not subject to any requirements of Annex II of MARPOL 73/78 in particular in respect of:

- the discharge of bilge or ballast water or other residues or mixtures containing only such substances
- the discharge into the sea of clean ballast or segregated ballast.

2 List of "easy chemicals"

2.1

2.1.1 The list of "easy chemicals" is given in Tab 1. The relevant symbols and notations used in Tab 1 are given in Tab 2.

Table 1 : List of easy chemicals *(1/1/2007)*

Product name	UN number	Pollution category	Tank vents	Elec. eqpt temp. class	Elec. eqpt apparatus group	Flash-point (°C)	Gauging	Vapour detection	Fire protection	High level alarm	Chem. family	Density (t/m³)	Melting point (°C)	Service notation
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)
Acetone	1090	Z	Cont	T1	IIA	-18	R	F	A	Y	18	0,79	-	FLS
Alcoholic beverages, not otherwise specified.	3065	Z	Cont	-	-	20 to 60 **(1)**	R	F	A	Y	-	1,00	-	FLS
Apple juice	-	OS	Open	-	-	NF	O	-	-	N	-	1,00	-	T
n-Butyl alcohol	1120	Z	Cont	T2	IIA	29	R	F	A	Y	20	0,81	-	FLS
sec-Butyl alcohol	1120	Z	Cont	T2	IIA	24	R	F	A	Y	20	0,81	-	FLS
Clay slurry	-	OS	Open	-	-	NF	O	-	-	N	-	1,50	-	T
Coal slurry	-	OS	Open	-	-	NF	O	-	A, B	N	-	1,50	-	T
Diethylene glycol	-	Z	Open	T3	IIB	>60	O	-	A	N	40	1,12	-	FLS>60
Ethyl alcohol	1170	Z	Cont	T2	IIA	13	R	F	A	Y	20	0,79	-	FLS
Ethylene carbonate	-	Z	Open	T2	-	>60	O	-	A	N	-	1,32	36	FLS>60
Glucose solution	-	OS	Open	-	-	NF	O	-	-	N	-	1,50	-	T
Glycerine	-	Z	Open	T2	IIA	>60	O	-	A	N	20	1,26	18	FLS>60
Glycerol monooleate	-	Z	-	-	-	-	-	-	-	-	-	-	-	-
Hexamethylenetetramine solutions	-	Z	Open	-	-	NF	O	-	-	N	7	1,50	-	T
Hexylene glycol	-	Z	Open	T2	IIA	>60	O	-	B, C	N	20	0,92	-	FLS>60
Isopropyl alcohol	1219	Z	Cont			22	R	F	A	Y	20	0,78	-	FLS
Kaolin slurry	-	OS	Open			NF	O	-	-	N	43	1,50	-	T
Magnesium hydroxide slurry	-	Z	Open	-	-	NF	O	-	-	N	-	1,23	-	T
Methyl propyl ketone	-	Z	Cont	-	-	<60	R	F	A	Y	18	0,82	-	FLS
N-Methylglucamine solution (70% or less)	-	Z	-	-	-	-	-	-	-	-	-	-	-	-
Molasses	-	OS	Open	-	-	>60	O	-	A	N	20	1,45	-	FLS>60
Noxious liquid (11), not otherwise specified, Cat. Z	-	Z	Cont	-	-	<60	R	F	A	Y	-	1,00	-	FLS
Non-noxious liquid (12), not otherwise specified, Cat. OS	-	OS	Cont	-	-	<60	R	F	A	Y	-	1,00	-	FLS

Product name	UN number	Pollution category	Tank vents	Elec. eqpt temp. class	Elec. eqpt apparatus group	Flash-point (°C)	Gauging	Vapour detection	Fire protection	High level alarm	Chem. family	Density (t/m^3)	Melting point (°C)	Service notation
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)
Polyaluminium chloride solution	-	Z	Open	-	-	NF	O	-	-	N	-	1,25	-	T
Potassium formate solutions	-	Z	-	-	-	-	-	-	-	-	-	-	-	-
Propylene carbonate	-	Z	-	-	-	-	-	-	-	-	-	-	-	-
Propylene glycol	-	Z	Open	T2	IIA	>60	O	-	A	N	20	1,03	-	FLS>60
Sodium acetate solutions	-	Z	Open	-	-	NF	O	-	-	N	-	1,45	-	T
Sodium sulphate solutions	-	Z	Open	-	-	NF	O	-	-	N	-	1,45	-	T
Tetraethylene glycol	-	Z	Open	-	-	>60	O	-	A	N	40	1,50	-	FLS>60
Tetraethyl silicate monomer/oligomer (20% in ethanol)	-	Z	-	-	-	-	-	-	-	-	-	-	-	-
Water	-	OS	Open	-	-	NF	O	-	-	N	-	1,00	-	T

(1) Composition dependent.
(2) Isomer dependent.
(3) Flashpoint not determined by a closed-cup method.
(4) Depends on acetate content.

Table 2 : Symbols and notations used in the list of easy chemicals

Items	Col.	Comments
Product name	(a)	Gives the alphabetical name of the products.
UN number	(b)	The number relating to each product shown in the recommendations proposed by the United Nations Committee of Experts on the Transport of Dangerous Goods. UN numbers, where available, are given for information only.
Pollution category	(c)	The letter Z refers to the pollution category Z as defined in Annex II of MARPOL 73/78. The symbol OS means that the product was evaluated and found to fall outside the pollution categories X, Y and Z defined in Annex II of MARPOL 73/78.
Tank vents	(d)	
Electrical equipment temperature class	(e)	The symbols T1 to T6 refer to the electrical equipment temperature classes defined in IEC Publication 79-0.
Electrical equipment apparatus group	(f)	The symbols IIA and IIB refer to the electrical equipment apparatus groups defined in IEC Publication 79-0.
Flashpoint	(g)	
Gauging	(h)	
Vapour detection	(i)	
Fire protection	(j)	The letters A, B, C and D refer to the following fire-extinguishing media determined to be effective for certain products: A : alcohol-resistant foam (or multi-purpose foam) B : regular foam, encompasses all foams that are not of an alcohol-resistant type, including fluoro-protein and aqueous-film-forming foam (AFFF) C : water spray D : dry chemical (powder).
High level alarm	(k)	
Chemical family	(l)	
Density	(m)	
Melting point	(n)	
Service notation	(o)	The symbols FLS, FLS>60 and T are defined as follows: FLS : means that the product is allowed to be carried by a ship having the service notation **FLS tanker** FLS>60 : means that the product is allowed to be carried by a ship having the service notation **FLS tanker**, **flash point > 60°C**, T : means that the product is allowed to be carried by a ship having the service notation **tanker**.