Rules for the Classification of Offshore Units

PART D – Service Notations

Chapter 1

NR 445.D1 DT R02 E **March 2007**

17 bis, Place des Reflets – La Défense 2 – 92400 Courbevoie
Postal Address : 92077 Paris La Défense Cedex
Tel. 33 (0) 1 42 91 52 91 – Fax. 33 (0) 1 42 91 53 20
Email : veristarinfo@bureauveritas.com
Web : http://www.veristar.com

MARINE DIVISION
GENERAL CONDITIONS

ARTICLE 1

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

The Society:

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

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

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

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

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

ARTICLE 2

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

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

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

2.4. - The Client is to give to the Society all access and information necessary for the performance of the requested Services.

ARTICLE 3

3.1. - The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are not a code of construction neither a guide for maintenance or a safety handbook.

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

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

3.3. - The Services of the Society are carried out by professional Surveyors according to the Code of Ethics of the Members of the International Association of Classification Societies (IACS).

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

ARTICLE 4

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

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

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

ARTICLE 5

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

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

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

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

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

ARTICLE 6

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

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

The Society bears no liability for indirect or consequential loss such as e.g. loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

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

ARTICLE 7

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

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

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

ARTICLE 8

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

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

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

ARTICLE 9

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

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

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

ARTICLE 10

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

ARTICLE 11

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

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

ARTICLE 12

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

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

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

ARTICLE 13

13.1. - These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement.

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

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

RULES FOR THE CLASSIFICATION OF OFFSHORE UNITS

Part D
Service Notations

Chapter **1**

March 2007

The English wording of these rules take precedence over editions in other languages.
Unless otherwise specified, these rules apply to units for which contracts are signed after June 1st, 2007. The Society may refer to the contents hereof before June 1st, 2007, as and when deemed necessary or appropriate.

CHAPTER 1
PRODUCTION, STORAGE AND OFFLOADING SURFACE UNITS

Section 1 General

Section 2 Subdivision and Stability

Section 3 Structure Design Principles

Section 4 Hydrodynamic Analysis

Section 5 Design Loads

Section 6 Hull Girder Strength

Section 7 Hull Scantlings

Section 8 Other Structures

Section 9 Local Structural Improvements

Section 10 Access, Openings, Ventilation and Venting of Spaces in the Storage Area

Section 11 Equipment and Safety Particulars

Section 12 Piping Systems

Section 13 Use of Process Gas and Crude Oil as Fuel

Section 14 Swivels and Risers

Part D
Service Notations

Chapter 1

PRODUCTION, STORAGE AND OFFLOADING SURFACE UNITS

SECTION 1 GENERAL

1 Application

1.1 General

1.1.1 The present Chapter deals with particular provisions applicable to floating units for production, and/or storage of hydrocarbons, and intended to receive one of the service notations listed in [1.2.1].

1.1.2 The Society reserves its right, whenever deemed necessary, to apply requirements of the present Chapter to units fitted with cargo or liquefied gas storage facilities, even if the unit is not intended to receive any of the service notations listed in [1.2.1].

1.1.3 Requirements of the present Chapter are complementary to provisions of Part A, Part B and Part C which remain applicable, except where otherwise specified.

1.2 Notations

1.2.1 Structural type and service notations

The requirements of the present Chapter apply to surface units having one of the following structural type and service notations:

- **offshore service barge – oil storage**
- **offshore service barge – production**
- **offshore service barge – oil storage / production**
- **oil tanker ESP / offshore service ship – oil storage**
- **oil tanker ESP / offshore service ship – production**
- **oil tanker ESP / offshore service ship – oil storage / production**

For the definition of those notations, see Part A, Chapter 1.

Service and structural type notations including **oil tanker ESP / offshore service ship** are granted only to ships having kept, in working order, their propulsion system and steering appliances and complying with the provisions of the present Rules.

Otherwise, the structural type notation **offshore service barge** is granted to surface type floating production and/or storage units, including the case of converted ships, when unable to perform non-assisted voyages.

1.2.2 Classification Society involvement

The scope of classification for units listed above is based on an appraisal of the integrated unit covering in general:

a) Hull, accommodation, helideck and hull attachments and appurtenances including:
   - riser support structure
   - structure to which the moorings are attached, and supports for mooring equipment
   - foundations for the support of topsides modules, the flare tower, and the hull mounted equipment
   - support structure for life saving appliances
   - passive fire protection and cathodic protection.

b) Intact and damage stability.

c) Marine equipment (with foundations) pertaining to the offloading facilities.

d) Accommodation quarters.

e) Mooring system:
   - mooring line components (anchors, chains, wire and accessories)
   - hull mounted equipment (fairleads, stoppers...)
   - mooring line handling equipment (winch, sheaves...).

f) Lifting appliances (in case of the additional class notation **ALM**).

g) Equipment and systems necessary for the safe operation of the hull and to the safety of personnel on board as defined in the Rules for the Classification of Offshore Units and related applicable Rules (taking into account the additional service features **AUTO** and **IG**, and the additional class notation **LSA**).

h) Equipment and systems installed in the hull, the failure of which may jeopardise the safety of the floating unit.

i) The fire and gas detection system for the hull as well as the definition of the hazardous areas of the hull.

j) The fire water and foam system for the protection of the hull.

k) Topsides process plant.

l) Propulsion plant.

Some of the systems and items mentioned in item g), h), i), j) and k) above are possibly positioned in topsides facilities and remain under scope of classification regardless of the additional class notation **PROC**.

When the service notation of the unit is **oil tanker ESP** or combination hereof, reference is also made to the Ship Rules for requirements related to this notation.

For each project, the detailed boundaries for the classification of **Offshore service barge** or **Offshore service ship** are defined by the Society on case by case basis and with reference to the requested structural type and service notations, additional class notations and additional service features.

Should the offloading system be connected to an offloading buoy, such unit is considered as a separate unit and is to be classed according to the Rule Note NR 494 “Rules for the Classification of Offshore Loading and Offloading Buoys”.

1.2.3 General application of the Rules

The provisions of these Rules are applicable to the design and construction of newbuild "ship shaped" units and to reassessment and conversion work of an existing unit or ship (see also [1.3.3], when converted to a unit covered by present document).

When reference is made to Ship Rules, the latest version of these ones is applicable (the definition of the term "Ship Rules" is given in [4.2.6]).

The Society reserves its right to refer to previous editions of Ship Rules for conversions.

The Society may consider the acceptance of alternatives to these Rules, provided that they are deemed equivalent to the Rules to the satisfaction of the Society.

1.2.4 Classification process

For units with service notations as given in [1.2.1] except combination with **oil tanker ESP**, the classification process prior to issuance of final class certificate includes towing from completion yard to site (see [1.7], hook-up operations and commissioning at site). For units with service notation **oil tanker ESP** or combination hereof, the classification process may lead to issuance of final certificate at an earlier stage depending on the actual intended service of the unit and possible commissioning activities at the constructing yard.

Procedures and detailed schedules for construction at each construction site together with towing, installation, anchoring and production hook-up, and commissioning activities are to be submitted to the Society for information. These documents are also to indicate the possible interfaces between the various Contractors to the Owner. Based on these documents, the Society prepares the survey program for inspection and drawing review.

1.2.5 Classification – Temporary conditions during construction

In accordance with the provisions of classification, any temporary conditions during fabrication, load out, intermediate towing between two construction sites before complete finalisation of the unit and final load out of topside modules are considered beyond scope of classification unless specific demand has been received from the party applying for classification.

The Society issues a provisional certificate upon completion of the hull and with design criteria for towing condition clearly identified.

Corrosion protection systems are to be arranged for the hull during the outfitting phase. The documentation is to be submitted to the Society for information. The Society may require thickness measurements to be carried out prior to leaving the yard.

1.2.6 Classification – Surveys during service

When the notation of the unit is **oil tanker ESP / offshore service ship**, the requirements for survey of ships with service notation **oil tanker ESP** as given in the "Ship Rules" are applicable. In addition, the Society may allow the continuous survey system for hull to be applied and may allow the bottom survey in dry-dock to be replaced by in-water survey.

For units classed as **offshore service barge**, the Society bases the inspection requirements as for **oil tanker ESP**. The Society adapts the required surveys to the specificities of these units in terms of operational conditions, which are to be documented and made available to the Society.

Prior to entering in service, a classification renewal plan listing the survey plan for the five year classification period must be submitted to and approved by the Society.

Regarding the mooring lines (within the scope of **POSA** service feature), the Inspection, Maintenance and Repair (IMR) plan for the station keeping system is to be agreed with the Society prior to entering in service.

RBI methodology may assist the Owner in defining more accurately required examinations, in co-operation with the Society.

The period of class means the period starting either from the date of the initial classification, or from the credited date of the last class renewal survey – and is generally 5 years.

1.2.7 Permanent installations

Surface units with notation as given in [1.2.1] are considered as permanent installations performing its service at a single location, or for a duration not less than, typically, 5 years on a single site.

A permanent installation is given a site notation consisting in the name of the unit operation field.

1.2.8 Non permanent installations

In case of mobile units not considered as permanent installations, special requirements are to be met based on the operating requirements. Such requirements are to be mentioned in the Design Criteria Statement which may influence not only the design but also the in-service inspections.

1.2.9 Navigation and site notations

Navigation and site notations are granted in accordance with the provisions of Part A, Chapter 1.

1.2.10 Additional service features

The following additional service features, as defined in Part A, are mandatory for units covered by the present Chapter (see [1.2.1]):

- **AUTO** (control and safety systems)
- **POSA** (mooring system of permanent offshore units)
- **IG** (inert gas system for cargo tanks)
- **VeriSTAR-Hull** (3D finite element model).

When a helideck is fitted onboard the unit, the additional service feature **HEL** is mandatory (see Ch 1, Sec 8, [6]).

Note 1: For other units than those covered by the present Chapter, these service features are optional.

1.2.11 Additional class notations

The following additional class notations may be granted to the unit:

- **STI** (specific thickness increments)
- **RIPRO** (risers)
- **PROC** (process)
- **DYNAPOS** (dynamic positioning)
- **ALP**, **ALM**, **ALS** (lifting appliances)
- **LSA** (life saving appliances)
- **COMF** (noise and vibration)
- **HIPS** (high integrity protection system).

In addition, additional class notations as given by the Ship Rules may be granted.

1.2.12 Comfort on board floating units

The notations dealt with under this heading are relevant to the assessment of comfort on board floating units with regard to the level of noise and/or vibration.

The parameters which are taken into consideration for the evaluation of the comfort such as the level of noise, and the level of vibration is indicated in the relevant annex to the Certificate of Classification.

The parameters are only verified once for all when the unit is classed.

As an initial approach, the requirements for the additional class notation **COMF**, taking into consideration realistic criteria upon the final evaluation of the unit and based on Owner requirements, are given in Part C, Chapter 5.

1.3 Structural requirements

1.3.1 Definition

Surface units are in principle similar to oil trading tankers with the main difference in the following parameters:

- site specific as opposed to ocean trading
- ocean trading only for voyage between constructing shipyard and intended site, and between different shipyards
- continuous loading and offloading operations at sea
- topsides facilities in continuous operations
- inspection, repair and maintenance at sea, with no dry-docking for the intended service life
- permanently moored.

Documentation of the above must be made available to the Society for reference.

1.3.2 Principles

The classification of surface units is expressed in terms of classification notations as given in Part A, Chapter 1. The name of the site where the unit will be in service is mentioned in addition to the navigation notation on the classification certificate.

Design loads and motions are to be evaluated based on the following:

a) Classification marks and notations

b) Environmental conditions (towing phases, site)

c) Production effects (lightweight, loading cases)

The estimated loads and motions from the hydrodynamic analysis are to be compared to the rule values given for the navigation notation granted to the surface unit in order to determine the rule design loads and motions.

The purpose of the hydrodynamic analysis is to conclude the complements and assumptions for applying the Ship Rules.

A Design Criteria Statement, issued by the Society, lists the services performed by the unit and the design conditions and other assumptions (including results of the hydrodynamic analysis) on the bases of which class is assigned to the unit.

Considering the intended service life with possible objective of no dry-docking during this period, accessibility for in-service inspections shall be considered during the detail design phase.

1.3.3 Conversions – Feasibility study

A feasibility study is required for projects based on conversion of existing seagoing ships to units with notations as given in [1.2.1].

As a minimum, complete re-measurements of the scantlings including comprehensive surveys are required to evaluate the condition of the unit. Minimum requirements are defined on a case by case basis.

1.3.4 Loads

The design of the structure is to consider relevant loading conditions and associated loads including:

a) still water conditions

b) extreme environmental conditions during unit's operation (100 year wave)

c) offloading conditions

d) limiting conditions before the disconnection from single point mooring, if relevant

e) conditions during maintenance or inspection operations

f) transit conditions, from the construction/conversion location to offshore site and between constructing shipyards, if more than one

g) loads induced by process and other equipment, in above conditions, as relevant

h) damaged conditions, in accordance with the provisions of Part B, Chapter 2 and Part B, Chapter 3, and taking into account the damage assumptions as given in Ch 1, Sec 2.

1.3.5 Hull attachments and appurtenances

Loads on the hull are to be clearly identified by shipyard or designer. All structures welded to the hull (such as major supports for topsides, flare tower, pipe rack and other hull appurtenances) should be considered regardless the actual scope of Classification for these structures. Loads are to be indicated for operation, design, towing and damage conditions.

When attached structures and equipment are designed by an independent contractor, the Society may require the Owner to provide additional design analysis integrating the loads on attached structures and structure design of the hull, if not foreseen in design specification.

The attachments and appurtenances are within scope of Classification if the supported equipment is within scope of Classification, mentioned elsewhere in the present Rules or essential for the safety of the unit. Otherwise, the interface between classed and non-classed part will be defined on a case by case basis.

1.3.6 Definition of ship areas

For the hull construction, and similarly to the approach for design detailed in the present document, the shipbuilding practice, industry and regulatory requirements, and the Ship Rules (as defined in [4.2.6]) are the base reference for the construction of hull current parts, including materials, detailing, welding qualification, fabrication tolerances and inspection (see Ch 1, Sec 3, [1.3]). Any deviation from these standards is to be clearly documented on construction drawings and in specifications.

When applying the Ship Rules for the design of the hull current parts, attention is to be paid to the loads specified in [1.3.4].

The Society reserves the right to require additional documentation for design of ship structures like skeg, bilge, equipment supports, etc.

1.3.7 Definition of offshore areas

For areas that are specific to the vessel service of an offshore service barge, such as turret or mooring supports, riser porches, topside supports, reference is made to Part B. More details are given in Ch 1, Sec 3, [1.2].

In case of conflict between the Ship Rules and the present Chapter, the latter one is to take precedence over the requirements of the Ship Rules.

1.4 Design life

1.4.1 The requirements about "Service Life", "Design life", unit modifications and unit re-assesment are given in Pt A, Ch 1, Sec 1, [1.7].

1.5 Station keeping

1.5.1 General

The purpose of positioning equipment and machinery is to maintain the unit on location, within station keeping requirements, in view of its designed functions.

The **POSA** additional and mandatory class notation covers the complete installation from anchors or piles and their fixation in seabed to the fastening devices on the unit hull for mooring. The provisions for classification are given in the Guidance Note NI 493 "Classification of Mooring Systems for Permanent Offshore Units".

The station keeping of the unit can be reached by a very large number of different design conditions, which are subject to review on a case by case basis.

a) Floating structures may use catenary, taut spread moorings and/or dynamic positioning systems. Mooring lines can be combined into a turret base (SPM – single point mooring) with a single point of contact to the hull of the floating unit or the lines may be connected to various positions on the hull (spread mooring system).

b) The floating unit may be connected to a fixed tower using a pendulum link arrangement instead of the mooring hawser.

c) Mooring System can be based on use of the Catenary Anchor Leg Mooring (CALM) concept (pendulum link or rigid arm connection to hull of floating unit).

d) External or internal turret in hull of floating structure enabling weathervaning of the hull – in particular for units positioned in severe environmental areas.

The assessment of a mooring system requires the evaluation of unit motions, and the resulting excursions and line tensions, under specified environmental conditions.

The structure parts of the station keeping system are to comply with Part B, Chapter 2 and Part B, Chapter 3 in addition to the provisions of the Guidance Note NI 493 "Classification of Mooring Systems for Permanent Offshore Units".

When the station keeping of the unit is achieved by means of a turret, the structure of the turret and structures connecting the turret to the hull, are to be designed in accordance with the provisions of Ch 1, Sec 8, [1.2].

When the station keeping of the unit is achieved by means of a spread mooring system, reference is made to Ch 1, Sec 8, [1.3].

1.5.2 Dynamic position systems

The mooring system may consist partly (combined with passive mooring systems as described in [1.5.1]) or entirely of dynamic positioning systems, for which the Society makes reference to the requirements given for the additional class notation **DYNAPOS** in the Ship Rules.

1.5.3 Mooring to buoy

The mooring of the floating unit may be assured through a buoy, which is a floating body, usually not manned, generally of a cylindrical shape, and fitted with mooring equipment as necessary. Such buoy may also ensure the fluid transfer between production and/or storage unit or onshore installation and the moored floating unit.

The buoy including its mooring system is to be classed by the Society and a separate certificate is issued. The arrangement of the buoy is to comply with the Rule Note NR 494 "Rules for the Classification of Offshore Loading and Offloading Buoys".

1.5.4 Mooring to existing buoy

For mooring to an existing Single Point Mooring (SPM) (possibly classed by other Classification Society) detailed documentation of the SPM is to be submitted to the Society for review. This documentation must include certificate, design and maintenance.

The Society reserves the right to require complete re-classification of the installation including remeasurement of lines and anchors.

1.6 Scope of additional class notations

1.6.1 Classed topsides – PROC notation

The structure of topside modules supporting entirely classed equipment is covered by class and is to be designed and built in accordance with the relevant requirements of Part B, Chapter 2 and Part B, Chapter 3.

When **PROC** additional class notation is granted, the structure of deck modules, flare boom and other structures housing production equipment and related facilities are to be designed and built in accordance with the relevant requirements of Part B, Chapter 2 and Part B, Chapter 3.

Subject to initial agreement, topsides structures, if not subject to green waters, may be designed following other recognized standards, provided due consideration is given to inertial loads, overall deformations of the unit, differential displacements of supports points and other relevant loadings, in accordance with the provisions of Part B, Chapter 2.

1.6.2 If PROC notation not requested

When **PROC** additional class notation is not requested, the structure of deck modules, flare boom and other structures housing production equipment is not covered by classification.

For equipment and piping installations, where classed systems within the hull have some part of their facilities located within the topsides, these facilities are covered by classification. The Society reserves the right to include in the scope of classification the structure of the supporting skid and its connection to the topside structure, even if this structure is mainly supporting production facilities.

For these equipment and systems, classification covers the equipment necessary to the proper operation of the concerned systems as requested by the Rules of the Society and related applicable Rules.

Classification excludes all the equipment only necessary to the operation of the topsides systems. For these systems, upon receiving specific information and request, the Society endeavours to verify that failure of equipment and system external to the scope of classification does not impair significantly hull installation. For structure supporting classed equipment, the attending Surveyor verifies the proper fitting of local supporting elements as indicated by the manufacturer of the equipment.

Particular attention is to be made to the design of the piperack on the main deck, which remain within scope of classification regardless of presence of pipes serving the topsides process plants.

A precise description of the scope of classification for what concerns the topside is given in Ch 1, Sec 8, [2].

The Fig 1 and the Fig 2 show examples of classification limits for different types of appurtenances.

Figure 1 :

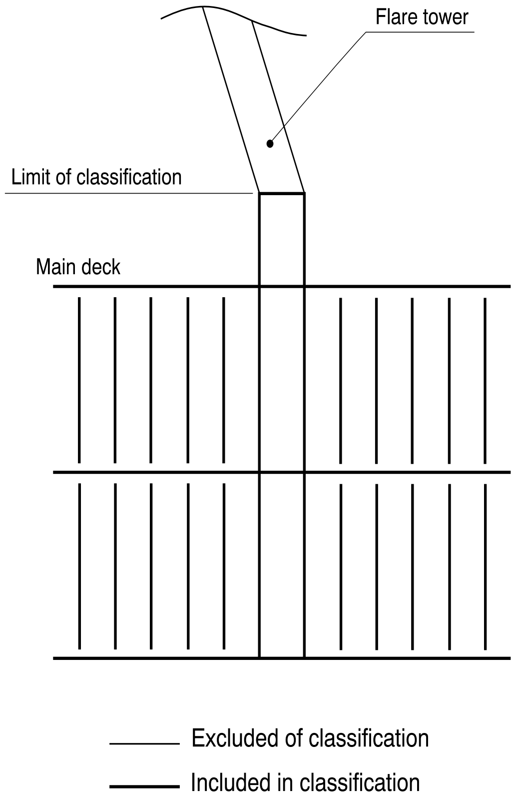
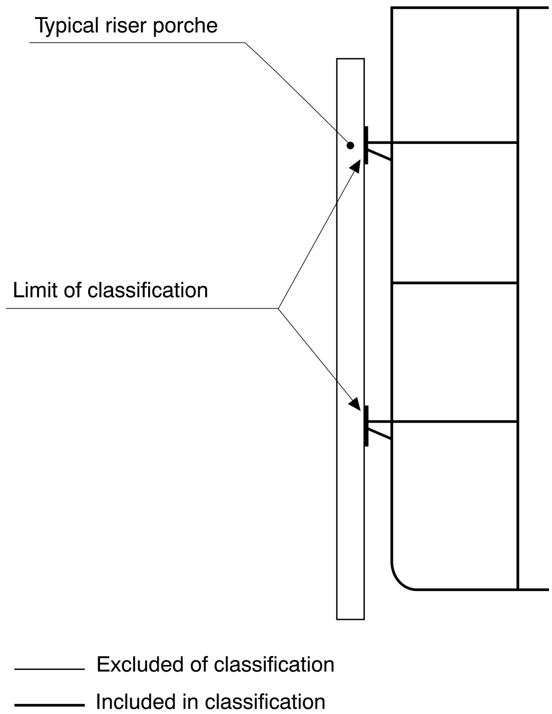


Figure 2 :



1.6.3 Riser attachment - RIPRO additional class notation

RIPRO additional class notation may be assigned to units fitted with risers meeting the corresponding requirement of Ch 1, Sec 14, [2].

In case the **RIPRO** additional class notation is not requested by the Owner, the classification is limited to the riser foundations securing the risers to the floating unit. Documentation of the estimated design loads is to be submitted to the Society for information.

As risers influence the anchoring system of the hull, the Society reserves its right to require appropriate documentation for the installation although the **RIPRO** additional class notation may not be requested.

Equipment fitted onboard for the installation of risers are considered as outside scope of classification unless requested by Owners or a notation for the lifting appliances is requested. The attachment of all equipment to the hull structure is covered by classification and it is to be documented that the resulting loads on the hull are based on wire breaking strength of used wires during installation.

1.6.4 Lifting appliances - ALP, ALM, ALS additional class notations

ALP, **ALM** and **ALS** additional class notations may be assigned to units equipped with cranes and other lifting appliances meeting the corresponding requirements of the NI 184 "Rules for the Classification and Certification of Lifting Appliances of Ships and Offshore Units" and NR 526 "Rules for the Classification and Certification of Cranes on bord Ships and Offshore Units".

When no additional notation for lifting appliances is granted, the classification covers only the crane pedestal and its foundation welded to the hull and based on loads specified by the designer. If the crane pedestal and its foundation are welded to a classed topside structure covered by the notation **PROC** this pedestal and its foundation is covered by class for the specific loads provided by the designer.

When the **ALP**, **ALM** and **ALS** notations are granted in agreement with NI 184 "Rules for the Classification and Certification of Lifting Appliances of Ships and Offshore Units" and NR 526 "Rules for the Classification and Certification of Cranes on bord Ships and Offshore Units" and the crane pedestal is partially or completely supported by a topside structure which is not covered by class (no additional **PROC** notation), then the crane pedestal and its foundation are not covered by class. In case this pedestal is connected to the topside structure and extended to the hull, then only the part of the pedestal connected to the hull is classed for specific loads provided by the shipyard.

The structure calculation for the crane pedestal and its foundation is to be submitted to the Society for information if not requested otherwise for classification.

Note 1: For additional notations **ALP**, **ALM** or **ALS**, the construction mark as defined in Pt A, Ch 1, Sec 2 is required.

1.7 Classification and towing

1.7.1 General

The towing or sailing by means of own propulsion system, between constructing shipyard and intended site is covered by classification requirements. It is recommended to flag the unit for the tow and mandatory in international waters and when people onboard. Attention is to be paid to compliance with international codes and standards as required by National Authorities.

In accordance with the provisions of classification, any temporary conditions during fabrication, load out, intermediate towing between two construction sites before complete finalisation of the unit and final load out of topside modules are considered beyond scope of classification unless specific demand has been received from the party applying for classification.

1.7.2 Navigation notation

As a rule, classification minimum criteria are scantlings as for a trading ship under **unrestricted navigation** for the specified draught and loading conditions during tow. Requirements given in the Ship Rules for this navigation notation are to be complied with.

1.7.3 Environmental conditions for tow

The Society may require detailed documentation for the intended route between the construction shipyard and intended site. Depending on the severity of this route, the planned time of the year and duration for the tow, further investigation of slamming loads, green waters, bow impact and ice loads, if any, may be required.

Towing criteria for extreme loads are generally specified by oceanographers or similar consulting companies. Scatter diagram (3 hours storm) with specified return period (usually 10 years) for each of the areas crossed during tow with seasonal variations indicated may be required by the Society.

Limitations on sea heading (avoidance of beam seas) including possible seasonal limitations must be defined by the Owner and/or party applying for classification.

1.7.4 Fatigue strength during tow

The Society reserves the right to require direct fatigue analysis for structural members as result of the tow. Such fatigue analysis is to be combined with the overall fatigue verification following the unit in operation.

Standard practice is to apply the Rule criteria for trading ships limited to simplified assessment of side shell stiffeners ensuring that the contribution of towing time in regards to fatigue damage is limited.

1.7.5 Temporary mooring during tow

The floating unit is to be equipped with temporary mooring (anchoring) equipment during the towing operation. This equipment may be removed when the unit is permanently moored at the operation site.

1.7.6 Emergency towing arrangement

The floating unit is to be equipped with an Emergency Towing Arrangement (ETA) as per IMO Resolution for seagoing tankers of same size.

Note 1: ETA is required in case the floating unit does not have to be moved from site, in circumstances where, likely, emptying and cleaning of tanks are not made. Alternatively, towing brackets or offloading hose brackets may be increased in strength to meet this requirement.

2 Rule application

2.1 Unit parts

2.1.1 The various Sections of the present Chapter are to be applied for the scantling and arrangement of unit parts according to Tab 1.

Table 1 : Sections applicable for the scantling of unit parts

<table>
<tr><td rowspan="2">Part</td><td colspan="2">Applicable Sections</td></tr>
<tr><td>General</td><td>Specific</td></tr>
<tr><td>Fore part</td><td rowspan="3">Ch 1, Sec 1
Ch 1, Sec 2
Ch 1, Sec 3
Ch 1, Sec 4
Ch 1, Sec 9</td><td>Ch 1, Sec 8, [3]</td></tr>
<tr><td>Central part</td><td>Ch 1, Sec 6
Ch 1, Sec 7</td></tr>
<tr><td>Aft part</td><td>Ch 1, Sec 8, [4]</td></tr>
</table>

2.2 Other items

2.2.1 The various Sections of the present Chapter are to be applied for the scantling and arrangement of other unit items according to Tab 2.

Table 2 : Sections applicable for the scantling of other items

Item	Applicable Article
Superstructures and deckhouses	Ch 1, Sec 8, [5]
Station keeping	Ch 1, Sec 8, [1]
Topside	Ch 1, Sec 8, [2]
Helicopter decks	Ch 1, Sec 8, [6]
Boat landing	Ch 1, Sec 8, [7]
Fore and aft parts	Ch 1, Sec 8, [3] Ch 1, Sec 8, [4]
Hull outfitting	Ch 1, Sec 8, [7]

3 Statutory requirements

3.1 General

3.1.1 Project specification

Prior to commencement of the review of drawings, the complete list of Rules, Codes and Statutory Requirements to be complied with must be submitted for information. This list is to detail the requirements to be complied with:

- International Rules
- Flag state requirements
- Coastal state requirements
- Owner standards and procedures
- Industry standards
- Classification notations.

The project specification is also to specify the list of Owner requested statutory certificates.

3.1.2 Conflict of Rules

In case of conflict between the Classification Rules and any Statutory Requirements as given by Flag state or Coastal State, the latter ones are to take precedence over the requirements of the present Rules.

In case of conflict between Owner or Industry standards and Classification Rules, the latter ones are normally to take precedence.

3.2 International Convention on Load Lines

3.2.1 Application

Compliance with the Load Line Convention may be required by Owner, Flag and/or Coastal State.

The Load Line Convention is in general applicable to units with structural and service notations as given in [1.2.1] for the towing phase. In case the unit has a flag when in service at site, application of the Load Line Convention may result in issuance of Load Line Certificate.

Application of ILLC has impact on stability requirements, see Ch 1, Sec 2.

3.2.2 ILLC at site

The Society verifies that the maximum draught of the unit is equal to or less than the draught derived from the calculation of the geometrical freeboard as given by the Load Line Convention and calculated as "tanker".

Operating draughts exceeding the maximum draught as given by this Convention may be accepted in special cases based on the severity of the environmental conditions and provided approval by Coastal state and/or Flag state.

3.3 MARPOL 73/78

3.3.1 Application

Although not mandatory for units covered by present Chapter, parts of the requirements in these Offshore Rules are similar to the ones in MARPOL and have to be complied with.

The Society recommends to apply the "Guidelines for application of MARPOL Annex 1 requirements to FPSOs and FSUs" as issued by IMO as document MEPC/Circ.406.

Compliance with MARPOL (in particular Annex 1, Rules 13F and 13G) may be required by Owner, Flag and/or Coastal State.

Note 1: MARPOL Annex 6 is generally applicable.

3.4 SOLAS

3.4.1 Application

Attention is drawn to the fact that SOLAS requirements may be applicable to the units covered by the present document at the request of competent authorities.

The provisions of the present Rules do not cover all SOLAS requirements.

3.5 IMO MODU

3.5.1 Application

Compliance with MODU may be required by Owner, Flag and/or Coastal State.

The Society reserves the right to refer to the requirements in MODU for fire fighting equipment for the helideck installation.

4 Symbols and definitions

4.1 General

4.1.1 Unless otherwise specified, the units, symbols, definitions and reference co-ordinate system given in Pt B, Ch 1, Sec 2 of the Ship Rules remain applicable.

4.1.2 In addition, specific definitions are given in [4.2].

4.2 Definitions

4.2.1 Floating production units

A floating production unit (FPU) is a unit fitted with processing equipment, as necessary to perform basic treatment (dewatering, degassing, gas compression, gas liquefaction, etc.) of hydrocarbons received from wells, prior to storage and/or export.

4.2.2 Floating storage units

A floating storage unit (FSU) is a surface unit intended for storage in bulk of liquid cargoes of flammable nature or liquefied gas.

4.2.3 Floating storage and offloading units

A floating storage and offloading unit (FSO) is a unit fitted with equipment for offloading stored hydrocarbons by shuttle oil tankers or liquefied gas carriers, moored alongside or in tandem mode.

Note 1: Export may alternatively be performed by an export flowline leading to another offshore installation (e.g. a loading buoy).

4.2.4 Floating production, storage and offloading units

Production and storage installations may be combined into a floating production and storage unit (FPSU) or into a floating, production, storage and offloading unit (FPSO).

4.2.5 Station keeping

A floating production and/or storage unit may be kept in position:

- either by means of a single point mooring to which she is moored or articulated, or
- by means of an independent anchoring system, or
- by means of a dynamic positioning system.

When provided, the anchoring system may consist of a spread mooring system, or a turret system.

The mooring system may be a disconnectable system, e.g. for units located in typhoon areas, which have kept their ship propulsion and steering appliances and can sail way in case of typhoon, or for units located in iceberg lanes.

An auxiliary propulsion system (thruster) may be fitted, e.g. to assist weathervaning, or to provide a minimum manoeuvrability to the unit, when disconnected.

4.2.6 Ship Rules

Following [1.2.3], when “Ship Rules” are mentioned in the present document, reference is made to the “Rules for the Classification of Steel Ships” for ships greater than 65 m in length. The designer has to contact the Society for information about any amendments to these Rules.

4.2.7 Rule length

For an offshore service unit with propulsion system, the rule length L is determined similarly to seagoing oil tankers (see Ship Rules). In case of units without rudder shaft, the rule length L is to be taken equal to 97% of the extreme length at the maximum draught.

The extreme length at the maximum draught is not to include external turret system or boat landing platforms possibly attached to the extreme ends.

4.2.8 Hull and superstructures

The hull is a barge shaped floating structure with overall dimensions in accordance with Pt B, Ch 5, Sec 2 of the Ship Rules. The purpose is to store oil (if applicable), ballast and production liquids. In addition, there are dedicated machinery spaces provided for essential generators, etc.

The definition of the hull includes the living quarters, which are to be designed and built in accordance with the relevant requirements for “superstructures” as given by Ship Rules. See also Ch 1, Sec 4, [2.1].

The hull includes supports for pertinent features of hull structure design, named “attachments and appurtenances in these rules, as for example hull topsides supports and foundations. The interface point is the bearing and sliding supports of the topside modules.

4.2.9 Topsides

A topside structure is usually an independent structure positioned on the deck of the floating unit which typically is the freeboard and strength deck. Depending the supporting arrangement, provisions are to be taken for possible effects of longitudinal stress and deformation from hull girder in the topsides structure. Topsides equipment may contain essential marine systems which are within scope of classification. The Society may require detailed documentation to be submitted for information.

The topsides are usually arranged in modules to ease fabrication, installation and to reduce impact from longitudinal stress in hull girder of the floating unit.

4.2.10 Maximum and minimum draught

The draught is the distance, in m, from the base line to the waterline, measured amidships.

The maximum draught is the deepest draught that can be observed at site during operation.

The minimum draught is the lightest draught that can be observed at site during operation.

4.2.11 Towing draught

For any towing phase, a maximum and minimum draught are to be determined by the designer – and reflected in the associated loading conditions.

4.2.12 Fore and aft parts

The fore part and aft part are determined on a case-by-case basis, according to the main wave heading.

4.2.13 Splash zone

The "splash zone" is the zone of the floating structure which is alternatively in and out of water due to wind, wave and motions. Surfaces which are wetted only during major storms are excluded from the splash zone.

The exact location and vertical extent of the splash zone is to be determined at the design stage as function of the environmental conditions at the intended site.

Unless otherwise indicated by the designer, the splash zone is usually considered as extending from 3 m below the lowest operational draught to 5 m above the maximum loaded draught.

Corrosion in the splash zone during service is to be controlled by means of protective coating systems and/or corrosion margins on plating

4.2.14 Cargo

For the application of this chapter, cargo means all the oil-like liquids in relation with the drilling and process (production) operation and includes also all the flammable liquids having a flash point of less than 60°C stored in bulk in cargo tanks of the unit.

4.2.15 Corrosion addition

Thickness to be added to the net thickness in view of corrosion allowance as defined in Ch 1, Sec 3, [3].

4.2.16 Thickness increment

Thickness that may be added to the gross thickness in accordance with Ch 1, Sec 3, [4].

4.3 Reference co-ordinate system

4.3.1 The ship's geometry, motions, accelerations and loads are defined with respect to the following right-hand co-ordinate system (see Fig 3):

- Origin: at the intersection among the longitudinal plane of symmetry of ship, the aft end of L and the baseline
- X axis: longitudinal axis, positive forwards
- Y axis: transverse axis, positive towards portside
- Z axis: vertical axis, positive upwards.

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

5 Calculations

5.1 Calculation programs for the rule based scantling

5.1.1 General

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

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

5.1.2 MARS FPSO

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

In particular, MARS allows to:

- calculate the transverse section geometric properties
- carry out the hull girder strength checks, including ultimate strength
- carry out the rule strength checks of:
  - strakes
  - longitudinal and transverse ordinary stiffeners
  - strakes and ordinary stiffeners of transverse bulkheads.

MARS permits the assessment of the fatigue life of structural details.

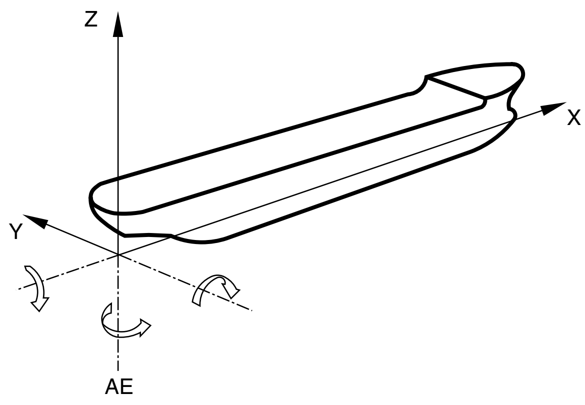
MARS also permits the re-assessment of in-service units calculating the steel renewal thickness based on rule required scantlings.

5.1.3 VeriSTAR

Within VeriSTAR system, the Society provides an integrated chain of computer programmes to perform rational design analysis of unit hulls.

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

Figure 3 : Reference co-ordinate system



VeriSTAR also permits the re-assessment of in-service units calculating the steel renewal thicknesses based on rule required scantlings.

5.1.4 Hydrostar

Within Hydrostar program, the Society provides a 3 dimensional diffraction radiation program that allows to perform the calculation of hydrodynamic loads and unit motions in the frequency domain.

5.2 Calculations to be submitted

5.2.1 Procedures

Procedures and assumptions taken for structural and hydrodynamic calculations requested by the Rules are to be submitted to the Society for review prior to submission of final report with conclusions of the analysis.

The following procedures must be submitted:

- Hydrodynamic calculations
- Finite element calculations:
  - primary supporting members of cargo tanks
  - topside supports
  - turret supports
  - spread mooring seats
  - fatigue structural details
  - topsides, if relevant
  - as a rule, spectral fatigue
- Additional calculation procedures for information:
  - dropped object analysis procedure
  - collision analysis procedure
  - explosion analysis procedure.

If the calculations are performed by means of other software than given in [5.1], detailed documentation may be requested by the Society to document the accuracy of the calculation.

5.2.2 Calculation report

The calculation report is to follow the procedure as described and agreed to prior to commencement of the study. Input data, considerations for decision of boundary conditions and detailed stress results must be available.

Finite element models usually consist of plate elements. Normal and shear stresses are usually obtained in the center of the element and stress plots are to show element stresses and not a node average.

Graphically information for the several loading condition is to show deformation of structure, numerical stresses and Von Mises values (for Offshore Rules criteria, BV equivalent stresses).

6 Design criteria and data

6.1 General

6.1.1 In accordance with the provisions of, the party applying for classification is to provide the Society with the classification data and assumptions.

Relevant information is entered in the Design Criteria Statement.

6.2 Site data

6.2.1 The party applying for classification is to specify the site at which the unit will operate, and is to provide relevant design data and background information.

Note 1: The case of a unit intended for several sites, or of a unit not being a permanent installation, is specially considered.

6.3 Operating loading conditions

6.3.1 General

The data on unit operation are to include the information required in [6.3.2] to [6.3.5].

6.3.2 General information

Characteristics of processed hydrocarbons and cargo intended to be stored (in particular H_2S content).

6.3.3 Environmental conditions

a) Extreme environmental conditions during unit's operation.

b) Most severe environmental conditions, if relevant, during offloading operations towards a shuttle oil tanker or liquefied gas carrier, moored alongside or in tandem mode.

c) Limiting conditions before the disconnection from single point mooring, if relevant.

d) Most severe environmental conditions, if relevant, during maintenance operations such as dismantling of main bearings of connection with single point mooring.

e) Environmental conditions during transit from construction/conversion location to offshore site, when not covered by a navigation notation.

6.3.4 Loads

a) Loads induced by connection to a single point mooring, if any, in all relevant conditions detailed in [6.3.3], including:
   - loads in bearings, in case of arm and yoke connections
   - loads on secondary bearings during maintenance operations.

b) Hawser loads, in case of connection by a hawser.

c) Maximum loads induced by shuttle oil tanker or gas carrier.

d) Loads induced by process and other equipment.

6.3.5 Ship loading condition

The following are to be considered:

a) loading conditions in normal operations, including distribution of stored hydrocarbon, ballast, stores and others, for the full sequence of loading-unloading of the unit

b) loading conditions in any other particular condition of operation of the unit, such as light ballast, or tank cleaning/inspection, and related limiting condition for environment

c) loading condition for transit.

Note 1: For control of loadings during operation, refer to Ch 1, Sec 5, [2.3].

7 Documentation to be submitted

7.1

7.1.1 The documentation to be submitted is to include the following information, in addition to what is specified in Part A, Chapter 1:

a) Design criteria and data, as defined in [6].

b) General drawings:
   - general arrangement of the unit, showing, as relevant:
     - the location of storage tanks with their openings, ballast tanks, cofferdams and void spaces, accesses to hazardous and safe spaces, cargo storage and production piping and vent piping on the open deck, bow or stern transfer lines, etc.
     - general arrangement of process, utility and control spaces
     - general arrangement of risers, riser supports, and manifolds
   - general arrangement of hazardous areas
   - flare radiation level plots
   - arrangement of the fore and aft spaces
   - general arrangement of the mooring system, or SPM connection.

c) Structural drawings, specifications and supporting documents:
   - booklet of loading conditions
   - mooring systems foundations (fairleads, tensioners, winches, bollards, etc.) where applicable
   - for a floating unit connected to a single point mooring by an arm or yoke, connections and supporting structure
   - turret structural and mechanical drawings
   - riser supports
   - foundations of deck modules and flare, if any, together with corresponding loads
   - deck modules, as relevant
   - flare structure
   - specification of coatings and drawings of cathodic protection, including outside hull and inside of tanks, with drawings of anode securing devices.

d) Machinery and piping drawings:
   - oil and gas processing plant (general arrangement, PID)
   - cargo offloading equipment
   - gas disposal system
   - diagrammatic cargo and gas piping systems, including offloading piping
   - connections to risers
   - diagrammatic drawing of stripping system of cofferdams, pump rooms and other spaces within the storage area
   - diagrammatic drawing of cargo tank vent systems
   - specification of pumps, valves, expansion joints and other cargo piping fittings
   - drawing of cargo pump shaft stuffing boxes at bulkhead penetrations
   - arrangement of gastight bulkhead penetrations
   - bilge and drainage systems for hazardous areas
   - ballast pumping within storage area
   - remote control of cargo and ballast pumping systems
   - specifications and drawings of cargo hoses
   - cargo tank heating system
   - crude oil tank washing systems, together with specification of equipment
   - arrangements for gas-freeing of cargo tanks
   - drawings of product swivels
   - drawings of electrical swivels
   - arrangements for venting cargo tanks, including specification of venting fittings
   - pressure-vacuum valves
   - arrangement and capacity of air ducts, fans and motors in storage area, together with justification of their anti-sparking properties
   - rotating parts and casings of fans
   - level-gauging arrangements, including drawings and specifications
   - emergency shut down system
   - remote control and monitoring systems, including specifications of instrumentation
   - arrangement of instrumentation in control stations.

e) Inert gas installations:
   - single-wire diagram of the installation, together with main characteristics: capacity, pressure, temperature, O_2 content, water content
   - list of the components with their characteristics: pipes, scrubber, blowers, non-return devices, valves, pumps, protective devices for overpressure and vacuum
   - drawing of arrangement of installation on board
   - diagram of monitoring and alarm systems
   - specifications of O_2 analyser, recorder and portable control instruments.

f) Safety plans:
   - drawing and specification of fire and gas detection systems
   - fire protection details in accommodation area
   - pressure water fire main
   - fire extinguishing systems in machinery and accommodation areas
   - foam extinguishing systems within storage area: diagrammatic arrangement drawing, calculation note, foam agent specification, characteristics of foam monitors and hoses

- fire extinguishing system in cargo pump rooms: general arrangement and calculation note
- fire extinguishing system in process area.

g) Others:

- documents relevant to contemplated additional notations, as specified in the Rules.

SECTION 2 SUBDIVISION AND STABILITY

1 General

1.1 Application

1.1.1 The present Section defines the subdivision and stability requirements, with respect to risks of capsizing or risks of pollution of the sea for units intended to receive a combination of notation among the ones given in Ch 1, Sec 1, [1.2.1], including storage.

1.1.2 The present Section is not applicable to units intended to receive a combination of notations not including storage.

2 Stability

2.1 General

2.1.1 Partially filled tanks

The free surface effects of partially filled tanks are to be taken into account in the stability calculations. Filling restrictions entered in the operating manual are to be given special consideration by the Society.

2.1.2 Documentation to be submitted

A stability file is to be submitted by the Owner or its representative. It should include line plans, capacity plans, justification of lightship characteristics, definitions of loading conditions, damage stability booklet, etc.

2.2 Intact stability

2.2.1 General

The requirements of Pt B, Ch 3, Sec 2 of the Ship Rules concerning the intact stability are applicable to the units covered by the present Chapter.

a) For inclining test and lightweight check:

The unit is to comply with the requirements of Pt B, Ch 3, App 1 of the Ship Rules.

b) For trim and stability booklet:

The information that is to be included in the trim and stability booklet is given in Pt B, Ch 3, App 2, [1.1] of the Ship Rules.

The loading conditions to be checked are given in [2.2.2].

c) In addition to the requirements of Pt B, Ch 3, Sec 2 of the Ship Rules, the criteria of Pt D, Ch 7, Sec 3, [1.2] of the Ship Rules are to be complied with.

2.2.2 Loading conditions

The following conditions are to be submitted:

- lightship condition
- transit condition during towing
- selected operational loading conditions covering foreseen fillings of the cargo tanks. One of the conditions should correspond to the maximum draught.

  For the assignment of a tropical freeboard, the corresponding loading condition has also to be submitted
- loading conditions for inspection of the cargo tanks, where one or two consecutive cargo tanks are empty (to be consistent with operational practice).

2.3 Damage stability

2.3.1 General

The unit is to comply with the requirements of Pt D, Ch 7, Sec 3, [1.3] of the Ship Rules which are similar to the ones in MARPOL.

However the extent of damage given in Pt D, Ch 7, Sec 3, Tab 1 of the Ship Rules is not fully applicable. The Table is to be replaced by the prescriptions given in [2.3.2].

2.3.2 Extent of damage

For the units covered in the present Chapter, the extent of damage on the bottom is disregarded.

The assumed extent of damage on the side shell is to be as follows:

- longitudinal extent:

  $l_c = 1/3\ L_{LL}^{2/3}$ or 14,5 m whichever is the lesser
- transverse extent:

  $t_c = B/5$ or 11,5 m whichever is the lesser
- vertical extent:

  v_c = without limit.

2.3.3 Type A freeboard

For units assigned with a type A freeboard, the requirements of Pt B, Ch 3, App 4 of the Ship Rules, which are similar to the ones in ILLC 66, are also to be complied with.

3 General arrangement of oil storage units

3.1 General

3.1.1 The requirements of this Article [3] are additional or replace, in case of conflict, those of Part C, Chapter 4.

3.2 Definitions

3.2.1 Storage area

The storage area is that part of the unit which contains cargo tanks as well as slop tanks, storage pump rooms, including any other rooms or spaces adjacent to storage tanks or slop tanks as well as deck areas throughout the entire length and breadth of the unit above the mentioned spaces.

3.2.2 Unit's manned end

Unit's manned end is the end of the unit where accommodation is located.

Note 1: in the case of most tankers converted into storage units or storage and accommodation units, manned end has the same meaning than aft end.

3.2.3 Unit's forward end

Unit's forward end is defined as:

- forward end, as usually considered, floating units intended to receive a combination of service and structural type notations including tanker/offshore service ship, irrespective of the end connected to a single point mooring, if any
- for newbuild barges articulated or moored to a single point mooring, the end next to this single point mooring
- for other units, the end constituting the forward end during towage.

3.2.4 Production equipment

Throughout the present Chapter, production equipment means equipment (piping and accessories, valves, pumps, pressure vessels, etc.) containing or liable to contain hydrocarbon products under treatment, excluding transfer from these production installations.

3.2.5 Cargo pump room

A cargo pump room is a space containing pumps and their accessories for the handling of cargo.

3.2.6 Pump room

A pump room is a space, possibly located in the storage area, containing pumps and their accessories for the handling of ballast and oil fuel, or other supplies, cargo being excluded.

3.2.7 Void space

A void space is an enclosed space in the storage area external to a cargo tank, except for hold space, cargo pump room, pump room, or any space normally used by personnel.

3.2.8 Other spaces

For definition of other spaces, refer to Part C, Chapter 4.

3.2.9 Independent piping system

An independent piping system designates a piping system for which no potential connection to other piping systems is available.

3.2.10 Separate piping system

A separate piping system designates a piping system which is not permanently connected to another piping system. This separation may be achieved by detachable spool pieces and valves and suitable blind flanges, or two spectacle flanges arranged in series with means between the two spectacles flanges to detect leakage.

Operational separation methods are normally not to be used within a cargo tank.

3.3 Cargo tanks

3.3.1 Segregation requirements

Cargo tanks and slop tanks 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 space.

3.3.2 Ends of storage area

A cofferdam or similar compartment is normally to be provided at both ends of the storage area. Such a cofferdam is to be bounded by oil-tight bulkheads 760 mm apart as a minimum and extending from keel to deck across the full breadth of the unit.

3.3.3 Double bottom

Double bottoms adjacent to cargo oil tanks are not to be used as oil fuel bunkers.

3.3.4 Arrangement of tanks

The size and arrangement of cargo tanks and ballast tanks located in the storage area are to comply with the applicable provisions of Article [2].

3.3.5 Fore and aft peaks

Cargo is not to be loaded in fore or aft peaks.

After special examination by the Society, newbuild floating units may be given a dispensation from the installation of a collision bulkhead or aft peak bulkhead provided that the corresponding extremity is efficiently protected by an SPM articulated to the unit.

3.4 Location and arrangement of spaces adjacent to storage area

3.4.1 Service notation including "oil tanker ESP"

Provisions of the Ship Rules applicable to oil tankers are also applicable to units intended to be granted a combination of service and structural type notations including **oil tanker ESP / offshore service ship**.

3.4.2 Machinery spaces

All machinery spaces are to be separated from cargo and slop tanks by cofferdams, cargo pump rooms, oil fuel bunkers or permanent ballast tanks.

However, the lower portion of the pump room may be recessed into the machinery spaces of category A to accommodate pumps provided that the deck head of the recess is in general not more than one third of the moulded depth above the keel. In the case of units of not more than 25000 tonnes deadweight, where it can be demonstrated that for reasons of access and satisfactory piping arrangement this is impracticable, the Society may permit a recess in excess of such height, but not exceeding one half of the moulded depth above the keel.

3.4.3 Ballast pump rooms

Pump rooms containing pumps and their accessories for the handling of ballast for spaces adjacent to cargo tanks and slop tanks and pumps for fuel oil transfer may be considered as equivalent to a cargo pump room for the application of [3.4.2] and Ch 1, Sec 10, [1.4], provided that such pump rooms fulfil the safety requirements applicable to cargo pump rooms.

The lower portion of pump rooms may be recessed into category A machinery space to accommodate pumps, provided that the deck head of the recess is not more than one third of the moulded depth above the keel.

3.4.4 Process and utility

Process and utility spaces may be located above main deck in the storage area.

Utility and control spaces, and other enclosed spaces, which are not themselves hazardous areas, are to be separated from deck by a distance of 3 m minimum, or by a cofferdam.

3.4.5 Accommodation, control and service spaces

Accommodation spaces, main cargo oil control stations, control stations and service spaces (excluding isolated cargo handling gear lockers) are to be positioned outside the storage area and cofferdams or other spaces (crude oil pump rooms, oil fuel bunkers or permanent ballast tanks) considered as equivalent isolating cargo oil or slop tanks from machinery spaces.

Note 1: A recess provided in accordance with [3.4.3] need not be taken into account when the position of these spaces is being determined.

3.5 Cargo pump rooms

3.5.1 Glazed ports in bulkheads

a) The cargo pump rooms are to be separated from the other spaces of the unit by oil tight bulkheads and are not to have any direct access to the machinery spaces.

b) Glazed ports can be provided in the bulkhead separating the cargo pump room from machinery spaces provided they satisfy the following conditions:

   - they are to be sufficiently protected from mechanical damage
   - strong covers are to be permanently secured on the machinery compartment side
   - glazed ports are to be so constructed that glass and sealing are not damaged by any deformations of the unit
   - the glazed ports are to be so constructed as to maintain the structural integrity and the bulkhead resistance to fire and smoke.

3.5.2 Bulkhead penetrations

The number of penetrations through the bulkhead separating the cargo pump room from the machinery spaces is to be kept to a minimum.

Any penetration through bulkheads or decks bordering the cargo pump room is to be of a type approved by the Society.

3.6 Drainage arrangements and slop tanks

3.6.1 Drainage arrangements

Drainage arrangements for safe areas are to be entirely separate and distinct from drainage arrangements from hazardous areas.

3.6.2 Deck spills

Means are to be provided to keep deck spills away from the accommodation and service areas. This may be accomplished by providing permanent continuous coaming of a suitable height extending from side to side.

3.6.3 MARPOL Convention

The attention of the Designer is drawn to the fact that the arrangements for the storage on board a unit, and the disposal of bilge and effluent from the production spaces are subject, outside the scope of classification, to requirements of the appropriate National Authority, in application of the MARPOL Convention.

3.6.4 Slop tanks

Slop tanks, where fitted in pump rooms, are to be of a closed type, air and sounding pipes being led to the open deck.

3.7 Ballasting of double bottom and narrow tanks

3.7.1 It is recommended to provide suitable arrangement for ballasting double bottom tanks and double hull tanks within storage area, if any, and cofferdams and other void spaces contiguous to storage tanks, in order to facilitate gas-freeing of such compartments.

SECTION 3 STRUCTURE DESIGN PRINCIPLES

1 Materials and testing

1.1 Definition of areas

1.1.1 Principles

Following analysis of the stress level in the structure and design environment, the Society may categorize some of the areas as "ship areas" or as "offshore areas".

Areas usually belonging to normal ship areas can be shown as critical by structural analysis.

Elements and types of areas are listed in Tab 1.

The Society reserves its right, according to appropriate structural analyses, to declare other elements as belonging to offshore areas.

Table 1 : Types of areas

Elements	Area
Flare tower supports	Offshore area
Turret moon pool, casing, and surrounding area	
Topsides supports at main deck	
Crane pedestals and foundation into hull	
Helideck support structure	
Mooring supports	
Hose handling crane pedestal and foundation into hull	
Offloading equipment foundations	
Riser porches and their foundations to the hull	
Other elements	Ship area

1.1.2 Offshore area requirements

Offshore areas listed in Tab 1 are to be in accordance with the requirements of Part B:

a) Concerned area is to include the part of the ship structure affected by the loads on listed elements.

b) Structural elements contributing to the longitudinal strength of the hull girder are also to comply with requirements given in the Ship Rules concerning the strength.

1.1.3 Ship area requirements

Ship areas listed in Tab 1 are to be in accordance with Pt B and Pt D, Ch 7 of the Ship Rules which remain applicable except where otherwise specified in the present Chapter.

In case of conflict between the Ship Rules and the present Chapter, the most severe is to take precedence.

1.1.4 Limits between ship areas and offshore areas

Limits between ship areas and offshore areas may be adjusted by the Society as a result of engineering judgement based on knowledge of the load path and related stress level.

1.2 Offshore areas

1.2.1 General

The steel grade of elements belonging to offshore areas, as defined in Tab 1, is to be determined in accordance with the requirements of Part B.

1.2.2 Definition

Offshore areas are separated in three categories (special, first and secondary) for the structural members.

These categories are defined in Pt B, Ch 3, Sec 2, [2].

For secondary category, the most stringent between Offshore Rules and Ship Rules for steel grade selection and welding requirements is to be applied.

1.2.3 Structural categories

Components in load transmission areas and contributing to the load path, include stiffener brackets, flanges etc. are to be classified as first or special category areas.

In principle, topside supports are to be categorized as first category elements with the highly stressed area as special category elements.

The helideck structure is considered as first category element but in general limited to the supporting structure.

1.3 Ship areas

1.3.1 The steel grade of elements belonging to ship areas as defined in Tab 1, is to be chosen in accordance with the Ship Rules.

1.4 Steels with specified through thickness properties

1.4.1 The designer is to evaluate the risk of any lamellar tearing, i.e. shrinkage stresses of the weld during cooling, clamping of the structure close to a joint, thickness of material, any rolling defects at mid-thickness and importance of the weld runs.

1.4.2 The maximum allowable stress through thickness is 50% of the allowable yield stress. For Z-grade plates as defined in the Ship Rules, a maximum stress of 75% of allowable yield stress can be accepted as through thickness stress.

Special attention to the welding of Z-grade plates is to be paid by the designer. The Society may require ultrasonic inspection before and after welding of the plate.

1.5 Inspection and checks

1.5.1 General

Materials, workmanship, structures and welded connections are to be subjected, at the beginning of the work, during construction and after completion, to inspections by the Shipyard suitable to check compliance with the applicable requirements, approved plans and standards.

The manufacturer is to make available to the attending Surveyor a list of the manual welders and welding operators and their respective qualifications.

The manufacturer's internal organisation is responsible for ensuring that welders and operators are not employed under improper conditions or beyond the limits of their respective qualifications and that welding procedures are adopted within the approved limits and under the appropriate operating conditions.

The manufacturer is responsible for ensuring that the operating conditions, welding procedures and work schedule are in accordance with the applicable requirements, approved plans and recognized good welding practice.

1.5.2 Inspection of ship areas

For parts of the structure defined as "ship areas", the requirements given in Pt B, Ch 12 of the Ship Rules are to be applied.

Prior to construction start, the constructing shipyard is to propose a recognized standard for approval.

The Society reserves the right to increase the number of non destructive examinations due to complexity of the structure compared to seagoing ships and with particular attention to the intended service.

1.5.3 Inspection of offshore areas

For parts of the structure defined as "offshore areas", reference is to be made to Section 6 of NR 426 "Construction Survey of Steel Structures of Offshore Units and Installations".

The Society reserves the right to increase the number of non destructive examinations due to complexity of the structure and with particular attention to the intended service.

2 Structural principles

2.1 Accessibility for inspection during service

2.1.1 Principle

Accessibility for inspection, and also for maintenance, is required with respect to the durability and integrity of the structure.

2.1.2 Underwater parts

For underwater parts, marking and arrangements to facilitate inspections are to be provided. Marking should be steel plate welded and painted.

Draught marks are to be provided at both sides at aft end, midship and bow.

Marks and identifying photographs shall be provided for orienting the diver (and submitted in copy to the Society for information). These shall include specific areas of plating, including locations of bulkheads and tanks, boundaries, sea chests (intake tubes), sea suction and discharge openings. Individual connections inside the sea chest (tube) are also to be identified.

Detailed drawings of the hull and hull attachments below the waterline are to be submitted to the Society for review.

2.1.3 Means of access

Complex areas like turret, riser porches, etc., must be accessible for inspection.

The means of access in the hull are to allow inspection of the critical structure connections identified during the drawing review by the Society and/or the designer.

The Regulation II-1/3-6 of the SOLAS Convention can be used as reference for the arrangement of the means of access in the hull.

The number of inaccessible areas is to be limited and clearly identified on the structure drawings. The Society reserves the right to require additional corrosion allowances for these areas. Special attention is to be paid to fatigue strength.

Direct access to non-cargo tanks such as wing and side ballast tanks and voids within the cargo hold block shall be provided from the hull main deck. Such spaces shall have their own access without passing through another such tank.

Web frame numbers shall be attached to structure or walkway inside of tanks to the satisfaction of the attending Surveyor.

Equipment on deck should be arranged to allow inspections of the deck plating and to avoid permanent concentration of dust and remaining water.

2.2 General construction

2.2.1 Typical arrangement

Large openings in web frames and stringers should be verified and necessary documentation / calculation notes are to be submitted to the Society.

As a guidance, two typical transverse structural configurations are shown in Fig 1 and Fig 2.

2.2.2 Structural continuity

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

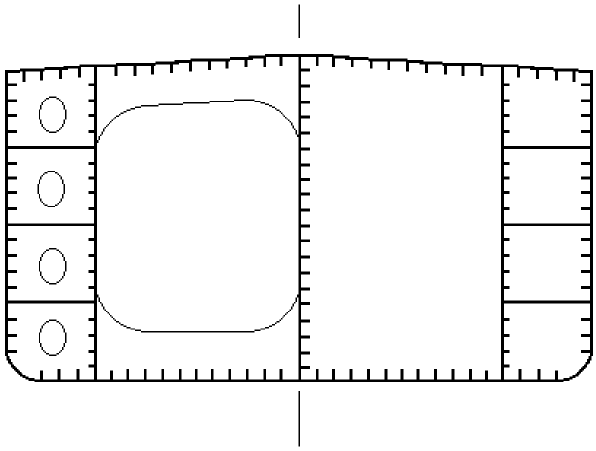
Attention is to be paid to the structural continuity:

- in way of changes in the framing system
- at the connections of primary or ordinary stiffeners
- in way of the ends of the cargo area
- in way of ends of superstructures.

Longitudinal members contributing to the hull girder longitudinal strength are to extend continuously for a sufficient distance towards the ends of the ship.

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

Figure 1 : Typical arrangement with longitudinal bulkhead in centre line



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

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

Openings are to be avoided, as far as practicable, in way of highly stressed areas.

Where necessary, the shape of openings is to be specially designed to reduce the stress concentration factors. Particular attention is to be paid to the passage of secondary stiffeners through web plating in the stress vicinity of heavy loads, i.e. top side loads on deck supports.

Openings are to be generally well rounded with smooth edges.

Primary supporting members are to be arranged in such a way that they ensure adequate continuity of strength. Abrupt changes in height or in cross-section are to be avoided.

2.2.3 Connections with higher strength steel

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

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

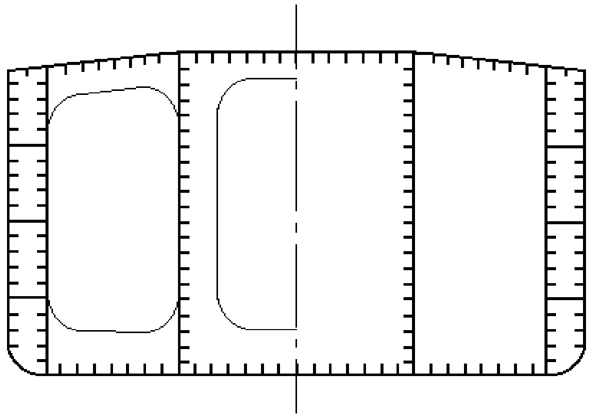
2.2.4 Docking brackets

The Society recommends fitting of docking brackets considering the future topside weight.

2.2.5 Bilge keel

If a bilge keel is fitted, requirements are given in Pt B, Ch 4, Sec 4 of the Ship Rules.

Figure 2 : Typical arrangement with two longitudinal bulkheads



2.2.6 Sniped ends

As a rule, sniped ends of primary and secondary stiffeners are to be less than 30 degrees as indicated on Fig 3.

2.3 Plating

2.3.1 A local increase in plating thickness is generally to be achieved through insert plates.

Insert plates are to be made of materials of a quality at least equal to that of the plates on which they are welded.

Plating under heavy concentrated loads shall be reinforced with doublers (only compression loads allowed) and/or stiffeners where necessary. Doublers in way of equipment and pipe rack supports are to be limited in size and avoided in areas of the deck with high stress. A detailed drawing showing location of the doublers is to be submitted to the Society for review.

2.4 Ordinary stiffeners

2.4.1 The requirements for the ordinary stiffeners are those given in Pt B, Ch 4, Sec 3, [3] of the Ship Rules.

2.5 Primary supporting members

2.5.1 General

In the cargo area, the primary structure is composed of transverse web frames, stringers, buttress, deck girders, cross-ties, etc.

2.5.2 Bracketed end connections

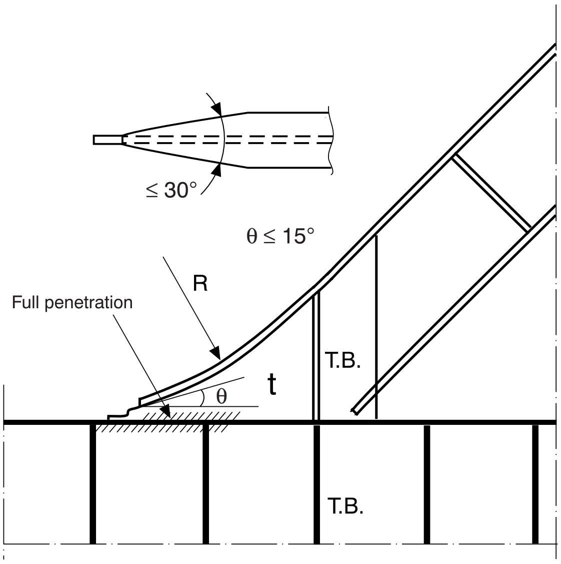
The primary supporting members are generally connected through brackets. These brackets are to comply with the following requirements.

a) Arm lengths of end brackets are to be equal, as far as practicable.

   With the exception of primary supporting members of transversely framed single sides (see Pt B, Ch 4, Sec 5 of the Ship Rules), the height of end brackets is to be not less than that of the primary supporting member.

b) The net thickness of the end bracket web is generally to be not less than that of the primary supporting member web.

Figure 3 : Bracket with symmetrical face plate



c) The net scantlings of end brackets are generally to be such that the net section modulus of the primary supporting member with end brackets is not less than that of the primary supporting member at mid-span.

d) The width, in mm, of the face plate of end brackets is to be not less than $50(L_b+1)$, where L_b is the length, in m, of the free edge of the end bracket.

Moreover, the net thickness of the face plate is to be not less than that of the bracket web.

e) Where deemed necessary, face plates of end connecting brackets are to be symmetrical. In such a case, the following requirements are in general to be complied with:

- face plates are to be tapered at ends with a total angle not greater than 30°
- the breath of face plates at ends is not to be greater than 25 mm
- face plates of 20 mm thick and above are to be tapered in thickness at their ends down to their mid-thickness
- bracket toes are to be of increased thickness
- an additional tripping bracket is to be fitted
- the radius R of the face plate is to be as large as possible
- collar plates welded to the plating are to be fitted in way of the bracket toes
- throat thickness of fillet welds is not to be less than t/2, with t being the thickness of the bracket toe.

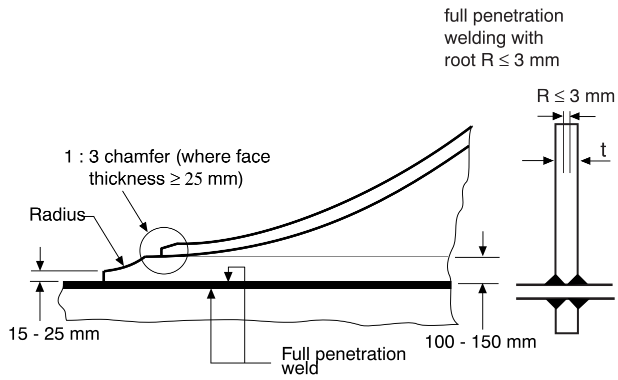
In general, full penetration welds should be applied as shown on the example of bracket with symmetrical face plate indicated in Fig 3 and Fig 4.

f) Stiffening of end brackets is to be designed such that it provides adequate buckling web stability.

As guidance, the following prescriptions may be applied:

- where the length L_b is greater than 1,5 m, the web of the bracket is to be stiffened

Figure 4 : Bracket with symmetrical face plate



- the net sectional area, in cm², of web stiffeners is to be not less than $16,5\ell$, where ℓ is the span, in m, of the stiffener
- tripping flat bars are to be fitted to prevent lateral buckling of web stiffeners. Where the width of the symmetrical face plate is greater than 400 mm, additional backing brackets are to be fitted.

g) In addition to the above requirements, the net scantling of end brackets are to comply with the applicable requirements given in [6].

2.5.3 Stiffening arrangement

a) Webs

Webs of primary supporting members are generally to be stiffened where the height, in mm, is greater than 100 t, where t is the web net thickness, in mm, of the primary supporting member.

In general, the web stiffeners of primary supporting members are to be spaced not more than 110 t.

b) Net sectional area

Where primary supporting member web stiffeners are welded to ordinary stiffener face plates, their net sectional area at the web stiffener mid-height is to be not less than the value obtained, in cm², from the following formula:

$$A = 0,1\ k_1\ (\gamma_{S2}\ p_S + \gamma_{W2}\ p_W)\ s\ \ell$$

where:

k_1 : Coefficient depending on the web connection with the ordinary stiffener, to be taken as:

- k_1 = 0,30 for connections without collar plate (see Fig 5)
- k_1 = 0,225 for connections with a collar plate (see Fig 6)
- k_1 = 0,20 for connections with one or two large collar plates (see Fig 7 and Fig 8)

p_S, p_W : Still water and wave pressure, respectively, in kN/m², acting on the ordinary stiffener, defined in Ch 1, Sec 4

γ_{S2}, γ_{W2} : Partial safety factors, defined in Ch 1, Sec 7 for yielding check (general).

Figure 5 : End connection of ordinary stiffener Without collar plate

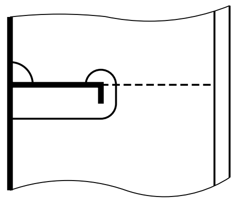
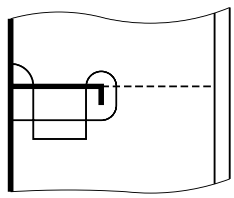


Figure 6 : End connection of ordinary stiffener Collar plate



c) Net section modulus

The net section modulus of web stiffeners of non-watertight primary supporting members is to be not less than the value obtained, in cm^3, from the following formula:

$w = 2,5\ s^2\ t\ S_s^2$

where:

- s : Length, in m, of web stiffeners
- t : Web net thickness, in mm, of the primary supporting member
- S_s : Spacing, in m, of web stiffeners.

Moreover, web stiffeners located in areas subject to compression stresses are to be checked for buckling in accordance with Ch 1, Sec 7.

d) Tripping brackets

Tripping brackets (see Fig 9) welded to the face plate are generally to be fitted:

- every fourth spacing of ordinary stiffeners, without exceeding 4 m
- at the toe of end brackets
- at rounded face plates
- in way of cross ties
- in way of concentrated loads.

Where the width of the symmetrical face plate is greater than 400 mm, backing brackets are to be fitted in way of the tripping brackets.

In general, the width of the primary supporting member face plate is to be not less than one tenth of the depth of the web, where tripping brackets are spaced as specified above.

The arm length of tripping brackets is to be not less than the greater of the following values, in m:

$$d = 0,38b$$

$$d = 0,85b\sqrt{\frac{s_t}{t}}$$

Figure 7 : End connection of ordinary stiffener One large collar plate

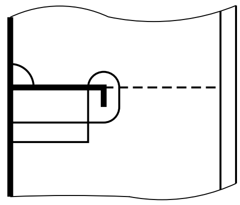
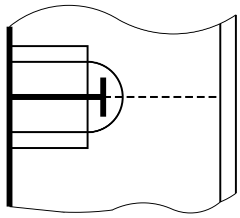


Figure 8 : End connection of ordinary stiffener Two large collar plates



where:

- b : Height, in m, of tripping brackets, shown in Fig 9
- s_t : Spacing, in m, of tripping brackets
- t : Net thickness, in mm, of tripping brackets.

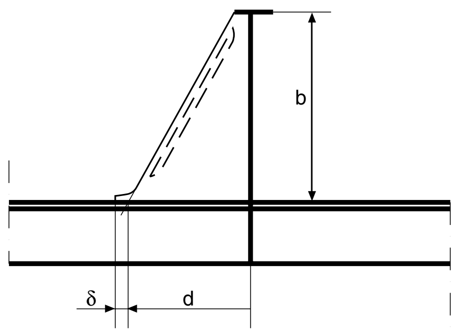
It is recommended that the bracket toe should be designed as shown in Fig 9.

Tripping brackets with a net thickness, in mm, less than $15L_b$ are to be flanged or stiffened by a welded face plate.

The net sectional area, in cm^2, of the flanged edge or the face plate is to be not less than $10L_b$, where L_b is the length, in m, of the free edge of the bracket.

Where the depth of tripping brackets is greater than 3 m, an additional stiffener is to be fitted parallel to the bracket free edge.

Figure 9 : Primary supporting member: web stiffener in way of ordinary stiffener



2.5.4 Strength checks of cross-ties analysed through a three dimensional finite element model

a) In addition to the requirements in Ch 1, Sec 7, 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 : Compression stress, in N/mm², obtained from a three dimensional finite element analysis, based on fine mesh modelling, according to Ch 1, Sec 7, [5]

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 (see Note 1)

I_{yy} : Net moment of inertia, in cm⁴, of the cross-tie about the y axis (see Note 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 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.

Note 1: The y axis is defined as the axis perpendicular to the cross-tie web. The x axis is that in the web plane (see Figures in Tab 2).

2.5.5 Buttress

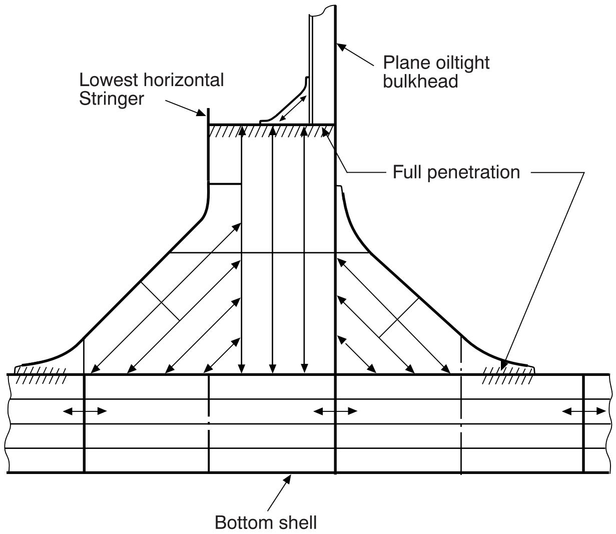
The buttress of transverse bulkhead is to be assessed through direct calculation, including fatigue.

The buttress is to be adequately stiffened, including tripping brackets according to [2.5.2].

The bracket ends are to be in accordance with [2.5.2].

In general, full penetration welds should be applied as shown on the example of buttress arrangement given in Fig 10.

Figure 10 : Buttress



2.5.6 Stringers

Stringers on bulkheads should be verified as swash bulkheads for sloshing. In case of risk of resonance, horizontal stringers are to be verified for the associated impact pressure on the adjacent bulkhead plating and stiffeners. Tripping brackets supporting the stringers are to be checked for loads as result of sloshing.

3 Net scantling approach

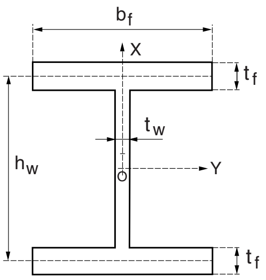
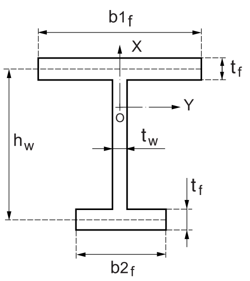
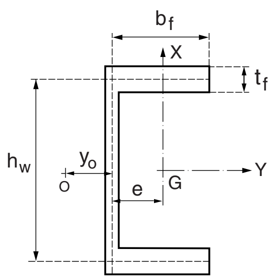
3.1 Principle

3.1.1 The scantlings obtained by applying the criteria specified in this Chapter and in applicable requirements of the Ship Rules are net scantlings (see Pt B, Ch 4, Sec 2, [1] and [2] of the Ship Rules).

3.2 Corrosion additions

3.2.1 The corrosion additions, as defined in Pt B, Ch 4, Sec 2, [3], of the Ship Rules are to be considered as a minimum. The net scantling plus the corrosion addition is equal to the gross thickness.

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	$\frac{1}{3}[(b_1 + b_2)t_f^3 + h_w t_w^3]$	$\frac{t_f h_w^2 b1_f^3 b2_f^3}{12(b1_f^3 + b2_f^3)}$
Non-symmetrical 	$\frac{b^2 t_f}{h t_w + 2b t_f}$	$\frac{3b_f^2 t_f}{6b_f t_f + h_w t_w}$	$\frac{1}{3}(2b_f t_f^3 + h_w t_w^3)$	$\frac{t_f b_f^3 h^2}{12} \frac{3b_f t_f + 2h_w t_w}{6b_f t_f + h_w t_w}$

4 Thickness increments

4.1 General

4.1.1 Principle

A thickness increment of platings and, where relevant, of stiffeners may be added to the gross thickness in special areas subject to mechanical wastage due to abrasion or in areas of difficult maintenance.

$t_{net} = t_{gross} - t_c$

$t_{gross} = t_{as\text{-}built} - t_i$

The gross thickness plus the thickness increment is equal to the as-built thickness.

Note 1: Net thickness, gross thickness and as-built thickness are defined in Ch 1, Sec 1.

4.1.2 Checking criteria

For the checking criteria specified in this Chapter and in applicable requirements of the Ship Rules the thickness increments are not to be considered.

4.2 Thickness increment values

4.2.1 Units without the additional class notation STI

When the additional class notation STI is not assigned to the unit, the thickness increments are to be taken equal to 0.

As a rule, thickness increments as given for seagoing tankers are to be applied as a minimum.

4.2.2 Units with the additional class notation STI

When the unit has the additional class notation STI, the thickness increments may be defined by the Owner or by the Society:

a) When the Owner provides its own thickness increments, it is to be notified to the Society where thickness increments are provided.

b) When the Owner does not provide its own thickness increments, the values to be considered are defined in Tab 3.

Adequate indications (location, value of thickness increments) are to be given in the relevant structural drawings.

Table 3 : Thickness increments

Structural element	Thickness increment, in mm
Strength deck	1
Bottom	1
Side shell above the maximum draught at site	1
Side shell below the minimum draught at site	1
Splash zone	5
Inner skin	1
Upper strake of longitudinal bulkhead	1
Lowest side stringer	1

5 Bulkhead structure

5.1 General

5.1.1 The requirements of the present [5] apply to longitudinal or transverse bulkhead structures.

Generally, plane bulkheads are to be applied. Longitudinal bulkheads are usually longitudinally stiffened and transverse bulkheads mainly vertically stiffened with horizontal stringers (primary structure).

The lower stringer on transverse bulkheads may be supported by buttress (see Fig 10).

5.1.2 General arrangement

The number and location of watertight bulkheads are to be in accordance with the relevant requirements given in Ch 1, Sec 2.

Longitudinal bulkheads are to terminate at transverse bulkheads and are to be effectively tapered to the adjoining structure at the ends and adequately extended in the machinery space, where applicable.

Where the longitudinal watertight bulkheads contribute to longitudinal strength, the plating thickness is to be uniform for a distance of at least 0,1D from the deck and bottom.

The structural continuity of the bulkhead vertical and horizontal primary supporting members with the surrounding supporting structures is to be carefully ensured.

The web height of vertical primary supporting members of longitudinal bulkheads may be gradually tapered from bottom to deck. The maximum acceptable taper, however, is 80 mm per metre.

5.1.3 Watertight bulkheads of trunks, tunnels, etc.

The requirements for watertight bulkheads of trunks, tunnels, etc. are given in Pt B, Ch, Sec 7, [1.3] of the Ship Rules.

5.1.4 Openings in watertight bulkheads

The requirements for openings in watertight bulkheads are given in Pt B, Ch, Sec 7, [1.4] of the Ship Rules.

5.1.5 Watertight doors

The requirements for watertight doors are given in Pt B, Ch, Sec 7, [1.5] of the Ship Rules.

5.2 Plane bulkheads

5.2.1 The requirements for plane bulkheads are given in Pt B, Ch, Sec 7, [2] of the Ship Rules.

Horizontal stringers and associated brackets are subject to fatigue loading and are to be accessible for inspection. The structural analysis of these stringers must take into account any openings for ladders and pipes.

Attention is also to be paid to possible sloshing loads.

5.2.2 The upper part of plane bulkheads (longitudinal and transversal) are to be adequately reinforced in way of topside supports.

5.2.3 Vertical secondary stiffeners

For floating units with single bottom special attention is to be paid to the connection of vertical stiffeners on transverse bulkheads and bottom longitudinals. Direct calculation is to be submitted for information.

Attention is also to be paid to possible sloshing loads.

5.3 Swash bulkheads

5.3.1 General

The present [5.3] applies to transverse and longitudinal swash bulkheads whose main purpose is to reduce the liquid motions in partly filled tanks.

5.3.2 Openings

The total area of openings in a transverse swash bulkhead is generally to be between 10% and 30% of the total bulkhead area.

In the upper, central and lower portions of the bulkhead (the depth of each portion being 1/3 of the bulkhead height), the areas of openings, expressed as percentages of the corresponding areas of these portions, are to be within the limits given in Tab 4.

In general, openings may not be cut within 0,15D from bottom and from deck.

Table 4 : Areas of openings in transverse swash bulkheads

Bulkhead portion	Lower limit	Upper limit
Upper	10%	15%
Central	10%	50%
Lower	2%	10%

5.4 Racking bulkheads

5.4.1 The Society may request racking bulkheads in the cargo area, if necessary.

The racking bulkheads are to be verified for design pressure indicated for the scantling of swash bulkheads.

The racking bulkheads are to be checked through direct calculations. Particular attention is to be paid to shear stress.

A racking bulkhead not complying with Tab 4 can not be considered as a swash bulkhead. In this case, the racking bulkhead is not to be taken into account in the sloshing calculation.

6 Bottom, side and deck structure

6.1 General

6.1.1 The requirements for bottom, side and deck structure are given respectively in Pt B, Ch 4, Sec 4, Sec 5 and Sec 6 of the Ship Rules.

6.1.2 The topside supports are to be fitted in way of bulkheads or beams.

6.2 Particular requirements for the side structure

6.2.1 Riser attachment

Equipment located on the side shell (e.g. risers, fenders) are to be fitted in way of primary supporting members.

7 Reinforcements in way of supporting structures for hull attachments

7.1 Local arrangement

7.1.1 Generally, the supports for attachments and appurtenances are to be fitted in way of longitudinal and transversal bulkheads or in way of deck beams. Other supports are to be fitted in way of large primary supporting members.

The main structure may be locally reinforced by means of insert plates.

When the supports are only located on transverse web beam, the longitudinal structure is to be adequately reinforced.

The cut out in the deck transverse for the passage of ordinary stiffeners are to be closed in way of supports.

Particular attention is to be paid to buckling below supports.

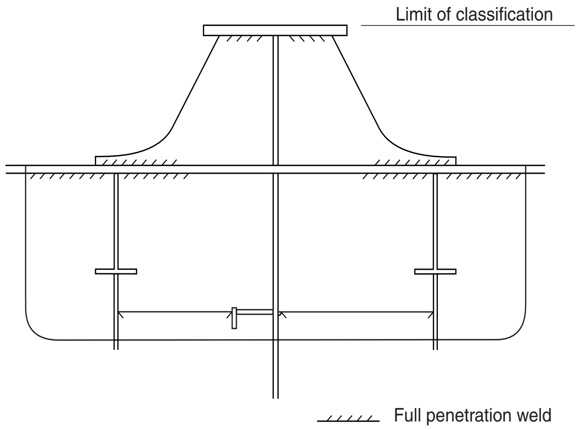
An example of local supporting structure for hull attachment is indicated in Fig 11.

8 Welding and weld connections

8.1 General

8.1.1 The standards applicable for offshore areas and for ship areas are different.

Figure 11 : Example of local reinforcements in way of supporting structure



8.2 Offshore areas

8.2.1 The NR 426 "Construction survey of steel structures of offshore units and installations" is to be applied for offshore areas.

8.2.2 For special category elements, the welds are to be full penetration welds. The surface of the external weld is to present a continuous and regular profile.

8.3 Ship areas

8.3.1 Pt B, Ch 12, Sec 1 of the Ship Rules are to be applied for ship areas.

8.3.2 For the members, the web is to be connected to the face plate by means of double continuous fillet welding.

It is recommended to use continuous fillet welding to connect the web to its associated shell plating. The throat thickness of such a welding is neither to be less than the value specified in Pt B, Ch 12, Sec 1, Tab 2 of the Ship Rules nor greater than 0,45 t.

Discontinuous welds and scallop welds are generally not allowed in the cargo tank area.

8.3.3 The welding factors for some hull structural connections are specified in Tab 5. These welding factors are to be used, in lieu of the corresponding factors specified in Pt B, Ch 12, Sec 1, Tab 2 of the Ship Rules to calculate the throat thickness of fillet weld T connections according to Pt B, Ch 12, Sec 1, [2.3] of the Ship Rules. For the connections of Tab 5, continuous fillet welding is to be adopted.

Table 5 : Welding factor w_F

Hull area	Connection of	Connection to	Welding factor w_F
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 **flash point > 60°C**.

Figure 12 : Reinforcement of throat thickness of a web frame

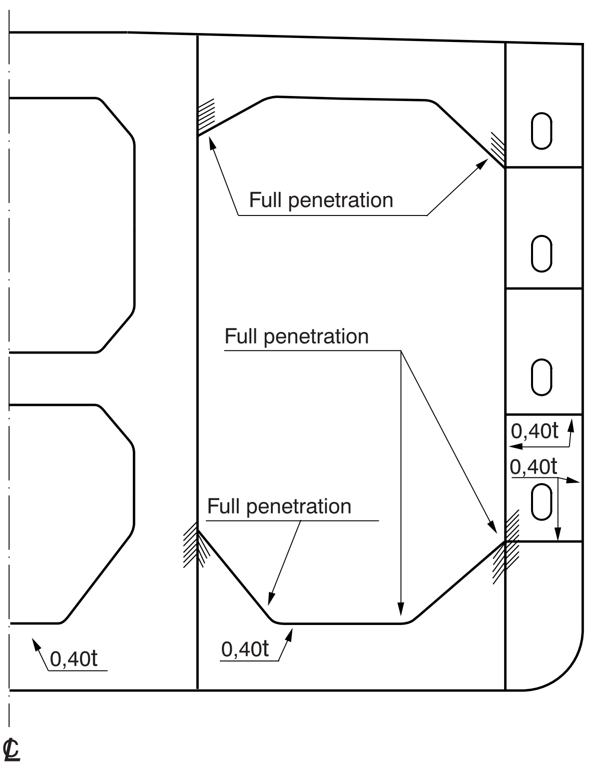
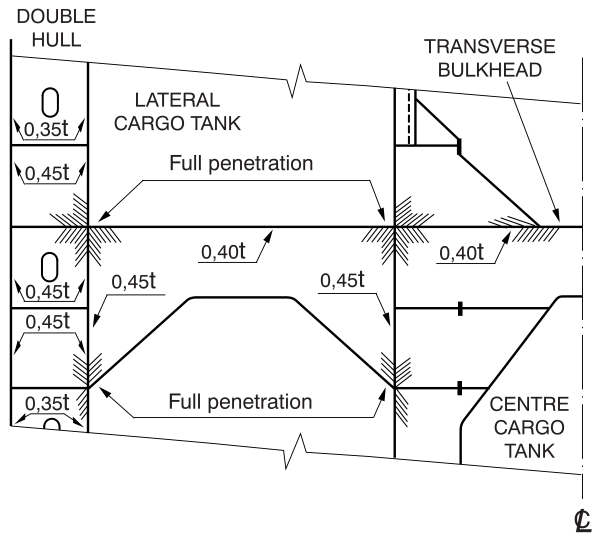


Figure 13 : Reinforcement of throat thickness for a stringer



8.3.4 Throat thickness of fillet welds for transverse web frames and horizontal stringers on transverse bulkheads are to be reinforced as shown in Fig 12 and Fig 13.

As a rule, the length, in m, of reinforcement is not to be less than the greater of the following values:

- $\ell = 2$ s
- $\ell = 1,2$

where s is the spacing, in m, of the ordinary stiffeners.

In general, full penetration welds should be applied as shown on Fig 12 and Fig 13

8.3.5 The minimum throat thickness of continuous fillet welding is not to be less than 4 mm for assemblies of high tensile steel.

SECTION 4 HYDRODYNAMIC ANALYSIS

1 General

1.1 Principle

1.1.1 The values of wave induced loads and motions are to be assessed through direct calculations. As an alternative the Society may accept the values of hull girder loads, unit motions and accelerations obtained from model tests.

The values of hull girder loads, unit motions and accelerations to be determined are those which can be reached with a probability level of $10^{-8,7}$.

The environment at site is to be defined through descriptive and quantitative data of the environment at site, over a long period of time (long term data) and by the characterization of the condition of sea at a given time, with reference to appropriate models (short time description).

The "long term" response of the vessel, with respect to both extreme condition and fatigue strength, is to be obtained by appropriate scanning over the "short term" response.

All relevant data is to be submitted to the Society for information.

1.2 Analysis

1.2.1 The purpose of the hydrodynamic analysis is to evaluate by direct calculation the design extreme values of parameters related to wave loading along the ship length and for the environmental condition at the site where the unit will operate. Analysis may also be performed for towing phases.

1.2.2 The hydrodynamic analysis is to be carried out using a recognized software, such as software Hydrostar of the Society. In particular, the use of a software based on three dimensional potential flow based diffraction radiation theory is required. Any other software is to be documented.

2 Modelling principles

2.1 Environmental data

2.1.1 General

Particular provisions of the present Section are complementary to provisions of Part B, Chapter 2, which remain applicable, except where otherwise specified.

2.1.2 Site parameters

The following environmental site parameters are required:

- wave directions
- wave spectrum with the specification of its characteristic parameters
- relative headings between the different components
- water depth.

In addition, general data concerning the site, such as:

- wind data (direction, force...)
- current direction

are to be submitted to the Society for information.

2.1.3 Scatter diagram

The sea state statistic data are generally provided under the form of a "scatter diagram" (table Significant wave – Wave period):

- T_P intervals of 1 second
- H_S interval of 1 meter
- number of occurrences, with reference duration of 3 hours.

The scatter diagram summarizes directions, together with number / percentage occurrence of each heading sector.

Information about extreme environmental conditions, either directional or seasonal extremes (typhoons, etc.) given by meteocean specialist, is to be separately explained in specification and is to be submitted to the Society for review.

2.2 Design conditions

2.2.1 The party applying for Classification is to derive as necessary from these data the characteristic parameters required for the purpose of Rules application.

The statistical techniques used to derive the required characteristic parameters are to be documented to the satisfaction of the Society.

2.3 Hydrodynamic model

2.3.1 The model should take into account the following effects:

- the unit hull forms with appendices, if any
- the light weight distribution (including structure weight topside weight, turret weight…)
- the loading conditions (see [2.4.1]
- the connections with the seabed (mooring, risers, etc.).

The wetted surface of the unit should be modelled by a sufficient number of elements. Size of elements in the model is to be consistent with the wave parameters (wave length and amplitude in particular).

2.4 Loading conditions

2.4.1 The following draughts and associated loading conditions are to be taken into account as a minimum:

- full load at maximum draught
- ballast load at minimum draught
- intermediate draught (with consideration of inertia distribution)
- loading condition giving maximum shear force in still water
- towing conditions.

2.5 Sensitivity analysis

2.5.1 A sensitivity analysis is required during hydrodynamic analysis.

Sensitivity analysis is to be performed based on variations of wave parameters (peak period, wave spectrum parameter, direction...) and other parameters (trim, loading of unit, etc.), if deemed relevant.

A heading study may be requested.

3 Unit response

3.1 Response amplitude operators

3.1.1 RAOs (Response amplitude Operators) and natural periods are to be calculated for each degree of freedom.

RAOs are to be calculated for different headings, generally, every 15°. The number of heading intervals may be reduced at the Society satisfaction.

Wave circular frequencies shall cover the anticipated sea states and spectra.

3.2 Hull girder loads, motions and accelerations

3.2.1 The hydrodynamic analysis should result in the following parameters valid for the offshore unit at the intended site and with precision of each value over the length of the unit:

- wave induced bending moment
- wave induced shear force
- total accelerations in the three directions, at the centre of gravity of each compartment and at relevant positions in topside areas
- relative wave elevation.

In site conditions these parameters are to be calculated based on a long term distribution (minimum probability level of $10^{-8,7}$) that is to be submitted. In lieu of this long term distribution, duly justified short term calculations may be considered by the Society.

In towing conditions these parameters are usually to be calculated based on a short term distribution which is to be submitted.

Diagrams representing the variations of the wave induced vertical bending moment, of the wave induced shear force and of the relative wave elevation over the length of the unit and for various headings is to be submitted to the Society for review.

3.3 Design values for structural analysis

3.3.1 The values of the parameters obtained in [3.2.1] may be modified or adjusted according to the experience of the Society: for the design review and structural analysis, the parameters are to be adjusted to profile according to the Ship Rules as stated in Ch 1, Sec 5, [3]. These profiles are to be specified in the final report of the hydrodynamic analysis.

Design values listed in [3.2.1] are used as follows:

- for yielding, buckling, longitudinal strength, ultimate strength checks, the values of the parameters at a probability level of $10^{-8,7}$ are used
- for fatigue the values of the parameters at a probability level of 10^{-5} are used.

SECTION 5 DESIGN LOADS

Symbols

L : Length, in m, as defined in Ch 1, Sec 1, [4.2.7]

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

B : Breadth, in m, as defined in Pt B, Ch 1, Sec 2, [3.1] of the Ship Rules

D : Depth, in m, as defined in Pt B, Ch 1, Sec 2, [3.5] of the Ship Rules

T : Maximum draught, in m, as defined in Ch 1, Sec 1, [4.2.10]

T_1 : Draught associated to the loading condition considered

C_B : Total block coefficient, equal to:

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

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

C : Wave parameter to be taken equal to:

$$C = (118 - 0,36L)\frac{L}{1000} \quad \text{for } 65m \le L < 90m$$

$$C = 10,75 - \left(\frac{300 - L}{100}\right)^{1,5} \quad \text{for } 90m \le L < 300m$$

$$C = 10,75 \quad \text{for } 300m \le L \le 350m$$

$$C = 10,75 - \left(\frac{L - 350}{150}\right)^{1,5} \quad \text{for } 350 < L \le 500m$$

h_W : Wave parameter, in m:

$$h_W = 11,44 - \left|\frac{L - 250}{110}\right|^3 \quad \text{for } L < 350m$$

$$h_W = \frac{200}{\sqrt{L}} \quad \text{for } 350 \le L \le 500m$$

a_{SU} : Surge acceleration, in m/s^2, defined in [3.3.1]

a_{SW} : Sway acceleration, in m/s^2, defined in [3.3.1]

a_H : Heave acceleration, in m/s^2, defined in [3.3.1]

α_R : Roll acceleration, in rad/s^2, defined in [3.3.1]

α_P : Pitch acceleration, in rad/s^2, defined in [3.3.1]

α_Y : Yaw acceleration, in rad/s^2, defined in [3.3.1]

A_R : Roll amplitude, in rad, defined in [3.3.1]

A_P : Pitch amplitude, in rad, defined in [3.3.1]

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

1 General

1.1 Principles

1.1.1 Application

The design loads are to be determined in accordance with the present Section and are to consider the relevant loading conditions and associated loads as listed in Ch 1, Sec 1, [1.3.4].

1.1.2 Site conditions

The floating unit is, in most cases, intended for use in a specified field, and a study of the loads induced by waves is to be performed through hydrodynamic analysis according to Ch 1, Sec 4, [3], combining the overall severity of the climate in the area and the vessel dimensions, shape and load distribution.

1.1.3 Towing conditions

The design loads of the unit are to be assessed in towing conditions.

The design loads are to be determined according to Part B, Chapter 5 and Part D, Chapter 7 of the Ship Rules, using the relevant navigation notation.

In case the hull girder loads, motions and accelerations given by the direct hydrodynamic calculation are greater than those given by the Ship Rules, special consideration will be given by the Society (see also Ch 1, Sec 1, [1.7.3]).

1.2 Definitions

1.2.1 The definitions of the following terms are indicated in Pt B, Ch 5, Sec 1, [1] of the Ship Rules:

- still water loads
- wave loads
- dynamic loads
- local loads
- hull girder loads
- loading condition
- load case.

1.3 Application criteria

1.3.1 Fields of application

The wave induced and dynamic loads defined in this Section are to be used for the determination of the hull girder strength and structural scantlings in the central part (see Pt B, Ch 1, Sec 1 of the Ship Rules).

1.3.2 Hull girder loads

The wave and dynamic hull girder loads to be used for the determination of:

- the hull girder strength, according to the requirements of Ch 1, Sec 6, and
- the structural scantling of platings, ordinary stiffeners and primary supporting members contributing to the hull girder strength, in combination with the local loads given in [6], according to the requirements in Ch 1, Sec 7,

are specified in this Section.

1.3.3 Load cases

The local loads defined in Pt B, Ch 5, Sec 1 of the Ship Rules for the towing conditions and in [5] and [6] for the site conditions are to be calculated in each of the mutually exclusive load cases described in [4].

Accidental loading cases according to Pt B, Ch 2, Sec 3, [1.5] are also to be calculated.

1.3.4 Ship motions and accelerations

The wave local loads are to be calculated on the basis of the reference values of ship motions and accelerations specified in [3.3].

1.3.5 Calculation and application of local loads

The criteria for calculating:

- still water local loads
- wave local loads on the basis of the reference values of ship motions and accelerations,

are specified in Pt B, Ch 5, Sec 1 of the Ship Rules for the towing conditions and in [5] and [6] for the site conditions.

1.3.6 Flooding conditions

The still water and wave pressures in flooding conditions are specified in [6.5]. The pressures in flooding conditions applicable to specific ship types are to be defined in accordance with the requirements in Part D, Chapter 7 of the Ship Rules.

1.3.7 Load definition criteria to be adopted in structural analyses of plates and secondary stiffeners

a) Application

The present requirement applies for the definition of local loads to be used in the scantling checks of plating according to Ch 1, Sec 7, [2] and ordinary stiffeners according to Ch 1, Sec 7, [3].

b) Load model

When calculating the local loads for the structural scantling of an element which separates two adjacent compartments, the latter may not be considered simultaneously loaded. The local loads to be used are those obtained considering the two compartments individually loaded.

For elements of the outer shell, the local loads are to be calculated considering separately:

- the still water and wave external sea pressures, considered as acting alone without any counteraction from the ship interior. This calculation is to be done considering the maximum draught at site,
- the still water and wave differential pressures (internal minus external sea pressure) considering the compartment adjacent to the outer shell as being loaded. This calculation is to be made considering the minimum draught at site. In case "b", the external pressure is to be taken equal to 0.

c) Minimum draught at site

In the absence of more precise information, the unit's minimum draught to be taken into account, in m, is to be obtained from the following formula:

$T_{mini} = 2 + 0,02\ L$

1.3.8 Load definition criteria to be adopted in structural analyses based on three dimensional structural models

The present requirement applies for the definition of local loads to be used in the scantling checks of primary supporting members. For primary supporting members a three dimensional structural model is required.

The most severe loading conditions and associated draught for the structural elements under investigation are specified in Ch 1, Sec 7, [5].

2 Still water loads

2.1 Loading manual

2.1.1 General

A loading manual is to be submitted for approval.

The loading manual is to be approved by the Owner.

The loading manual is, as a minimum, to be in compliance with the requirements of Pt B, Ch 11, Sec 2, [2] and Pt B, Ch 11, Sec 2, [3] of the Ship Rules for the service notation **oil tanker ESP**.

In addition the requirements given in [2.1.2] to [2.1.8] are to be satisfied.

2.1.2 Lightweight

The lightweight distribution is to be submitted.

The estimation and distribution of the lightweight is to include the topside loads:

- in dry conditions for towing
- in wet conditions at site (including loads from mooring system in case of pre-tension in lines).

Interface management quality plan for co-ordination between shipyard and topsides fabrication yard is to be addressed; Procedures for transfer of data for update of stability manual to be addressed.

Lightweight of topsides and hull are to be identified independently.

2.1.3 Principle for loading conditions

For a floating unit with mainly ongoing loading/unloading process a special study is to be carried out to evaluate the sequence of filling with respect to draught, trim and heel restrictions, if any. Attention is to be paid to minimizing free surface areas (sloshing, stability).

The study is initially to provide the envelopes of still water bending moment and shear force, and the data for a certain number of load patterns, for which the strength of primary structure will be evaluated, as specified in the present Chapter.

2.1.4 Design loading conditions

The hull girder is to be designed to allow flexibility in cargo loading. Any combination of adjacent empty and full cargo tanks should be permitted over the full operating draught range (transit draught to scantling draught), with the limitation of allowable bending moment, shear force and minimum draught or otherwise as approved by the Owner.

The design loading conditions are to be separated into five categories:

- maximum / minimum conditions
- intermediate conditions
- inspection conditions
- towing or sailing condition to intended site
- accidental loading conditions.

2.1.5 Maximum / minimum loading conditions

The maximum condition is to consider the unit with maximum draught and with all compartments filled to their maximum capacity.

The minimum conditions are to be divided into installation condition at site and minimum operational draught.

2.1.6 Intermediate loading conditions

Several intermediate loading conditions must be evaluated in the loading booklet to reflect the constant loading/ unloading process and to estimate the maximum values of still water bending moment and shear force.

The intermediate loading conditions must be based on the operating requirements which need to be mentioned in the loading booklet.

The intermediate conditions must also reflect the difference in loading and unloading sequences.

The Society reserves its right to require further loading conditions to take into account change in loading pattern as a consequence of human failure and pump system abnormalities (redundancy of pumps).

2.1.7 Inspection and repair loading conditions

Inspection and repair conditions have usually to be combined with the same values for wave loads as given for the maximum, minimum and intermediate conditions.

However, for units anchored in areas with occasional severe weather conditions (such as tropical hurricanes), certain reductions of the wave loads may be considered for those conditions. In other words, an increase of the still water bending moment and still water shear force above the maximum values defined by maximum, minimum and intermediate conditions may be accepted provided the Owners written agreement.

2.1.8 Towing or sailing condition to intended site

The loading cases for the towing or sailing between shipyard and the intended site must be available in the loading booklet. Values of trim and draught must be chosen to reduce the slamming and bow impact on the unit.

The criteria of the Rules for the towing condition is based directly on the magnitude and distribution of the still water bending moment, shear force and draught. The loading case is therefore to be available early in the design phase.

2.1.9 Accidental loading cases

The design of the floating unit is to consider the possibility of accidental loads as may result from collisions, dropped objects, fire or explosions (see Pt B, Ch 2, Sec 1, [4.1]).

Accidental loading cases are required for the towing phase and on site.

In accidental conditions, environmental loads are to be evaluated taking into account the circumstances in which the considered situation may realistically occur, and the time needed for evacuation or other remedial action. In principle, the return period of such environmental loads need not to be taken greater than 1 month.

2.2 Hull girder still water loads

2.2.1 Still water bending moment distribution

Design or allowable still water bending moment distribution is to be presented in a diagram or a table showing the values for bending moment at the position of centre of each compartment and at each transverse bulkhead.

Still water bending moment distribution indicated in Pt B, Ch 5, Sec 2, [2] of the Ship Rules is not applicable to offshore units.

2.2.2 Still water shear force distribution

Design or allowable still water shear force distribution is to be presented in a diagram or a table showing the values for shear force at the position of each transverse bulkhead.

2.3 Loading instrument

2.3.1 The loading instruments are to be in accordance with the requirements of Pt B, Ch 11, Sec 2, [4] of the Ship Rules. A floating unit with service notation as given in Ch 1, Sec 1, [1.2.1], is considered as belonging to “Category I ships”.

2.3.2 The loading instrument is also to perform stability calculations according with the procedures indicated in the Ship Rules as referenced above.

3 Wave loads

3.1 Factors of environment

3.1.1 Definition

Factors of environment are to be determined in accordance with the results of the hydrodynamic calculations. The factors of environment are chosen in such a way that the rule values and the values given by the direct calculation of the design load parameters are in well accordance.

Factors of environment apply only to wave loads.

The selected values of the design load parameters are to be superior or equal to the values calculated through the hydrodynamic analysis.

The factors of environment are the following ones:

f_{VBM} : Factor of environment for vertical wave bending moment

f_{HBM} : Factor of environment for horizontal wave bending moment

f_{VSF} : Factor of environment for vertical wave shear force

f_{RWE} : Factor of environment for relative wave elevation in upright ship condition

f_{aB} : Factor of environment for the wave parameter a_B as defined in [3.3.1]. In case there is no navigation notation, accelerations could be taken directly from hydrodynamic calculations

f_{deck} : Factor of environment for the wave pressure on deck. f_{deck} may be taken equal to f_{RWE}.

3.1.2 Values of factors of environment

At preliminary stage, if the hydrodynamic calculation is not available, the Society may accept factors of environment determined by the Designer, if duly justified.

The factors of environment are to be taken not less than 0,65.

Factors of environment may not be constant along the length of the unit hull.

3.1.3 Navigation notation

In case a navigation notation is granted to the unit, the values of all the factors of environment are to be taken as given in Tab 1. In addition, the values of all the factors of environment determined according to [3.1.1] and [3.1.2] are to be less than those given in Tab 1 for the considered navigation notation.

Table 1 : Navigation coefficients

Navigation notation	Factors of environment
Unrestricted navigation	1,00
Summer zone	0,90
Tropical zone	0,80
Coastal area	0,80
Sheltered area	0,65

3.2 Hull girder wave loads

3.2.1 Vertical wave bending moment

The vertical wave bending moments at any hull transverse section in upright ship condition are obtained, in kN.m, from the following formulae:

- hogging conditions:

  $M_{WV,H} = 190\, f_{VBM}\, F_M\, C\, L^2\, B\, C_B\, 10^{-3}$

- sagging conditions:

  $M_{WV,S} = -\, 110\, f_{VBM}\, F_M\, C\, L^2\, B\, (C_B + 0,7)\, 10^{-3}$

where:

f_{VBM} : Factor of environment defined in [3.1]

F_M : Distribution factor defined in Tab 2 (see also Fig 1).

Table 2 : Distribution factor F_M

Hull transverse section location	Distribution factor F_M
$0 \le x < 0,4\, L$	$2,5\frac{x}{L}$
$0,4\, L \le x < 0,65\, L$	1
$0,65\, L \le x < L$	$2,86\left(1 - \frac{x}{L}\right)$

Figure 1 : Distribution factor F_M

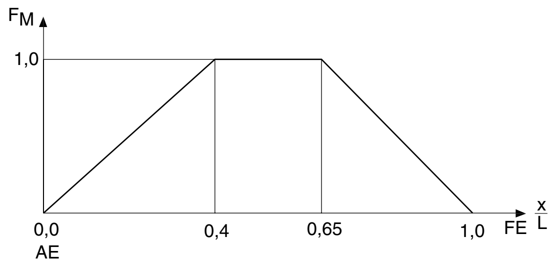


Table 3 : Distribution factor F_Q

Hull transverse section location	Distribution factor F_Q	
	Positive wave shear force	Negative wave shear force
$0 \le x < 0,2\, L$	$4,6A\frac{x}{L}$	$-4,6\frac{x}{L}$
$0,2\, L \le x \le 0,3\, L$	0,92 A	– 0,92
$0,3\, L < x < 0,4\, L$	$(9,2A - 7)\left(0,4 - \frac{x}{L}\right) + 0,7$	$-2,2\left(0,4 - \frac{x}{L}\right) - 0,7$
$0,4\, L \le x \le 0,6\, L$	0,7	– 0,7
$0,6\, L < x < 0,7\, L$	$3\left(\frac{x}{L} - 0,6\right) + 0,7$	$-(10A - 7)\left(\frac{x}{L} - 0,6\right) - 0,7$
$0,7\, L \le x \le 0,85\, L$	1	– A
$0,85\, L < x \le L$	$6,67\left(1 - \frac{x}{L}\right)$	$-6,67A\left(1 - \frac{x}{L}\right)$
Note 1: $A = \frac{190C_B}{110(C_B + 0,7)}$		

3.2.2 Horizontal wave bending moment

The horizontal wave bending moment at any hull transverse section is obtained, in kN.m, from the following formula:

$M_{HW} = 0{,}42\ f_{HBM}\ F_M\ H\ L^2\ T\ C_B$

where:

f_{HBM} : Factor of environment defined in [3.1]

F_M : Distribution factor defined in Fig 1

H : Wave parameter:

$$H = 8{,}13 - \left(\frac{250 - 0{,}7L}{125}\right)^3$$

without being taken greater than 8,13.

3.2.3 Vertical wave shear force

The vertical wave shear force at any hull transverse section is obtained, in kN.m, from the following formula:

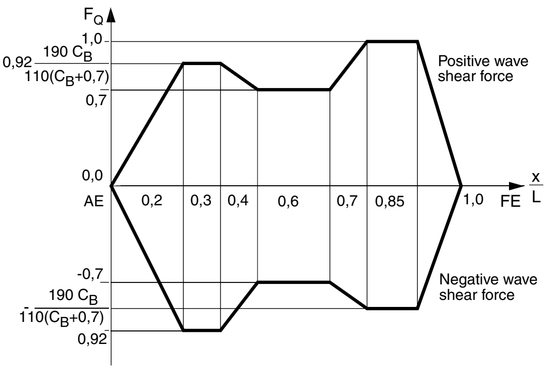
$Q_{WV} = 30\ f_{VSF}\ F_Q\ C\ L\ B\ (C_B + 0{,}7)\ 10^{-2}$

where:

f_{VSF} : Factor of environment defined in [3.1]

F_Q : Distribution factor defined in Tab 3 (see also Fig 2).

Figure 2 : Distribution factor F_Q



3.3 Unit motions and accelerations

3.3.1 Unit absolute motions and global accelerations

Absolute motions and accelerations of the unit are to be determined according to Pt B, Ch 5, Sec 3, [2] of the Ship Rules taking into account the following modifications:

- the motion and acceleration parameter a_B is to be taken equal to:

$$a_B = f_{aB}\left(\frac{2{,}4}{\sqrt{L}} + 3\frac{h_W}{L}\right)$$

where:

f_{aB} : Factor of environment, defined in [3.1] generally taken equal to the values given in Tab 1, according to the severity of the environment and/or the navigation notation that may be granted to the unit

- the surge acceleration a_{SU}, in m/s², is to be taken equal to 0,8 f_{aB}
- for the calculation of motions and accelerations, GM may be taken as for Ship Rules for oil tanker.

3.3.2 Relative wave elevation in upright ship conditions

The reference value of the relative wave elevation in upright ship condition is obtained, at any hull transverse section, from the formulae in Tab 4.

Table 4 : Relative wave elevation

Location	Reference value of the relative wave elevation h_1 in upright ship condition, in m
$x = 0$	$0{,}7\left(\frac{4{,}35}{\sqrt{C_B}} - 3{,}25\right)h_{1,M}$ if $C_B < 0{,}875$ $h_{1,M}$ if $C_B \geq 0{,}875$
$0 < x < 0{,}3L$	$h_{1,AE} - \frac{h_{1,AE} - h_{1,M}}{0{,}3}\frac{x}{L}$
$0{,}3L \leq x \leq 0{,}7L$	$0{,}67\ f_{RWE}\ C\ (C_B + 0{,}7)$
$0{,}7L < x < L$	$h_{1,M} + \frac{h_{1,FE} - h_{1,M}}{0{,}3}\left(\frac{x}{L} - 0{,}7\right)$
$x = L$	$\left(\frac{4{,}35}{\sqrt{C_B}} - 3{,}25\right)h_{1,M}$
Note 1: f_{RWE} : Factor of environment defined in [3.1] $h_{1,AE}$: Reference value h_1 calculated for $x = 0$ $h_{1,M}$: Reference value h_1 calculated for $x = 0{,}5\ L$ $h_{1,FE}$: Reference value h_1 calculated for $x = L$	

3.3.3 Relative wave elevation in inclined ship conditions

The reference value, in m, of the relative wave elevation in inclined ship condition, at any hull transverse section, is given by:

$$h_2 = 0{,}5h_1 + A_R\frac{B_W}{2}$$

where:

h_1 : Reference value, in m, of the relative wave elevation in upright ship, calculated according to the formulae of Tab 4

B_W : Moulded breadth, in m, measured at the waterline at draught T_1 at the hull transverse section considered

A_R : Roll amplitude, in rad, as defined in [3.3.1].

The value of h_2 may be increased depending on the results values of the hydrodynamic analysis.

3.3.4 Local accelerations

The values of the total longitudinal, transverse and vertical accelerations at any point are obtained from the formulae in Tab 5 and in Tab 6 for upright and inclined ship conditions.

The case where the accelerations calculated through direct analysis are greater than those given in Tab 5 and in Tab 6 is to be specially considered.

The values of the accelerations given in Tab 5 and Tab 6 may be increased depending on the result values of the hydrodynamic analysis.

Note 1: Cases "a", "b", "c" and "d" are defined in [4].

Table 5 : Total accelerations in upright ship condition (cases “a” and “b”)

Direction	Total accelerations a_{TX1}, a_{TY1}, a_{TZ1} (m/s²)
X - Longitudinal	$a_{TX1} = \sqrt{a_{SU}^2 + [A_P g + \alpha_p (z - T_1)]^2}$
Y - Transversal	$a_{TY1} = 0$
Z - Vertical	$a_{TZ1} = \sqrt{a_H^2 + \alpha_p^2 K_X L^2} + g$
Note 1: K_X : Coefficient to be taken equal to: $K_X = 1,2\left(\frac{x}{L}\right)^2 - 1,1\frac{x}{L} + 0,2$ without being taken less than 0,018	

Table 6 : Total accelerations in inclined ship condition (cases “c” and “d”)

Direction	Total accelerations a_{TX2}, a_{TY2}, a_{TZ2} (m/s²)
X - Longitudinal	$a_{TX2} = 0$
Y - Transversal	$a_{TY2} = C_{FA}\sqrt{a_{SW}^2 + [A_R g + \alpha_R (z - T_1)]^2 + \alpha_Y^2 K_X L^2}$
Z - Vertical	$a_{TZ2} = C_{FA}\sqrt{0,25 a_H^2 + \alpha_R^2 y^2} + g$
Note 1: K_X : Coefficient defined in Tab 5 C_{FA} : Combination factor to be taken equal to: • 0,7 for load case “c” • 1,0 for load case “d” For the definition of cases “c” and “d”, see [4].	

Figure 3 : Wave loads in load case “a crest”

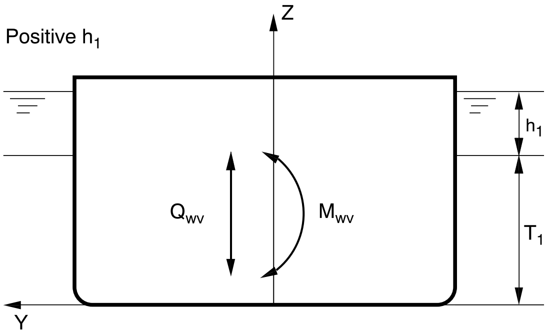
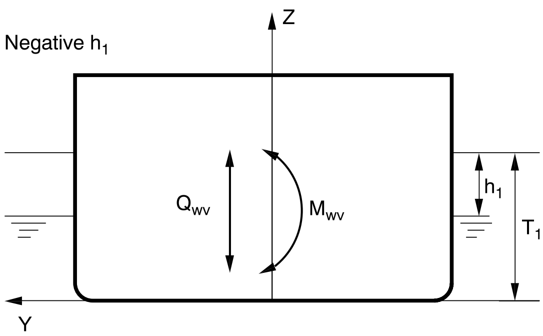


Figure 4 : Wave loads in load case “a trough”



4 Load cases

4.1 General

4.1.1 Load cases to be considered according to the type of structural analysis are to be in accordance with Pt B, Ch 5, Sec 4, [1] of the Ship Rules.

However the wave loads and hull girder loads to be considered in each load case are summarized in Tab 7 and Tab 8.

These loads are obtained by multiplying, for each load case, the reference value of each wave load by the relevant combination factor.

Note 1: Pt B, Ch 5, Sec 4, Fig 1 to Pt B, Ch 5, Sec 4, Fig 4 of the Ship Rules are to be replaced by Fig 3 to Fig 7.

Figure 5 : Wave loads in load case “b”

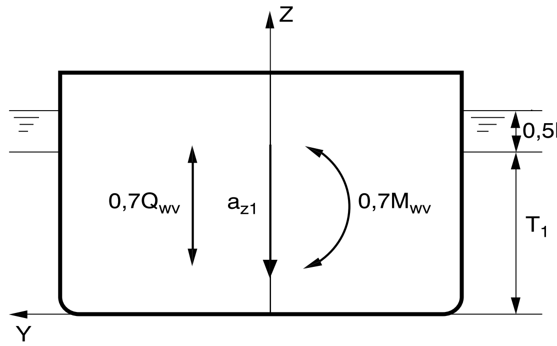


Figure 6 : Wave loads in load case “c”

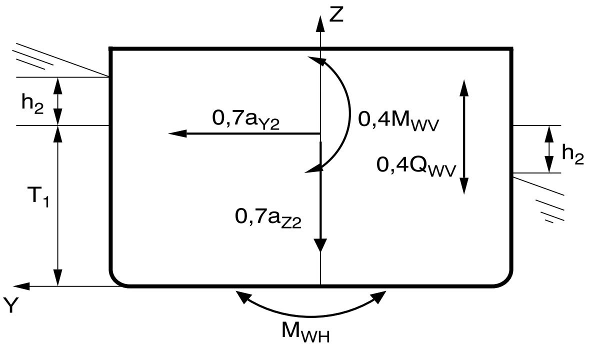


Figure 7 : Wave loads in load case “d”

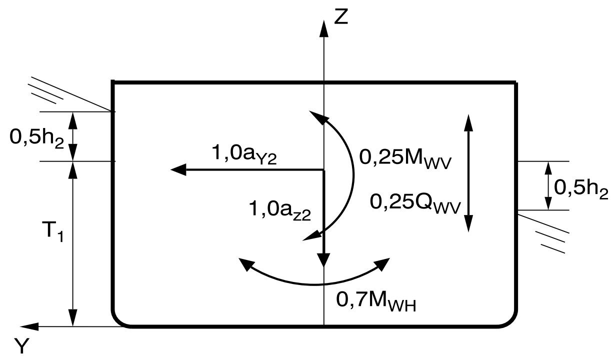


Table 7 : Wave local loads in each load case

Ship condition	Load case	Relative wave elevations		Accelerations a_X, a_Y, a_Z	
		Reference value	Combination factor	Reference value	Combination factor
Upright	"a"	h_1	1,0	no acceleration taken into account for case "a"	
	"b" **(1)** **(3)**		0,5	a_{X1}; 0; a_{Z1}	1,0
Inclined	"c" **(2)**	h_2	1,0	0; a_{Y2}; a_{Z2}	C_{FA} = 0,7
	"d" **(2)**		0,5	0; a_{Y2}; a_{Z2}	C_{FA} = 1,0

(1) For a ship moving with a positive heave motion:
- h_1 is positive
- the cargo acceleration a_{X1} is directed towards the positive part of the X axis
- the cargo acceleration a_{Z1} is directed towards the negative part of the Z axis.

(2) For a ship rolling with a negative roll angle:
- h_2 is positive for the points located in the positive part of the Y axis and, vice-versa, is negative for the points located in the negative part of the Y axis
- the cargo acceleration a_{Y2} is directed towards the positive part of the Y axis
- the cargo acceleration a_{Z2} is directed towards the negative part of the Z axis for the points located in the positive part of the Y axis and, vice-versa, is directed towards the positive part of the Z axis for the points located in the negative part of the Y axis.

(3) For plating and ordinary stiffeners, refer to [1.3.7]

Table 8 : Wave hull girder loads in each load case

Ship condition	Load case	Vertical bending moment		Vertical shear force		Horizontal bending moment	
		Reference value	Comb. factor	Reference value	Comb. factor	Reference value	Comb. factor
Upright	"a"	M_{WV}	1,0	Q_{WV}	1,0	M_{WH}	0,0
	"b"		0,7		0,7		
Inclined	"c"	M_{WV}	0,4	Q_{WV}	0,4	M_{WH}	1,0
	"d"		0,25		0,25		0,7

Note 1: The sign of the hull girder loads, to be considered in association with the wave local loads for the scantling of plating, ordinary stiffeners and primary supporting members contributing to the hull girder longitudinal strength, is defined in Ch 1, Sec 7.

Note 2: The combination factors used for direct calculations are given in Ch 1, Sec 7, [5].

5 Sea pressures

5.1 General

5.1.1 The sea pressures to be taken into account are those given in the present Article [5].

However the Society may accept calculations based on pressures coming directly from hydrodynamic calculation, if duly justified.

5.2 Still water pressure

5.2.1 Still water pressure on sides and bottom, and pressure on exposed decks are to be calculated according to Pt B, Ch 5, Sec 5, [1] of the Ship Rules.

5.3 Wave pressure in upright ship conditions

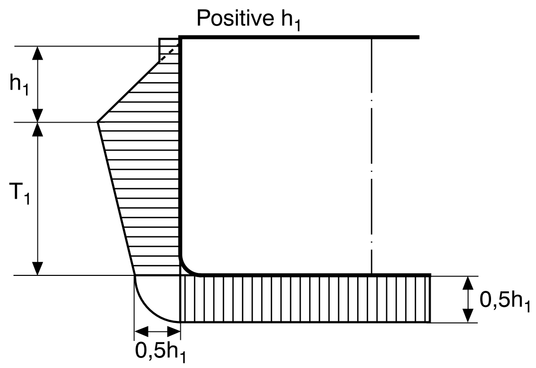
5.3.1 Pressure on sides and bottom

The wave pressure in upright ship conditions at any point of the hull is obtained from the formulae given in Tab 9.

5.3.2 Pressure on exposed decks

The wave pressure on exposed decks is to be considered for load cases "a crest" and "b crest" only. This pressure is obtained from the formulae given in Tab 10.

Figure 8 : Wave pressure on sides and bottom in upright ship conditions (load cases "a crest")



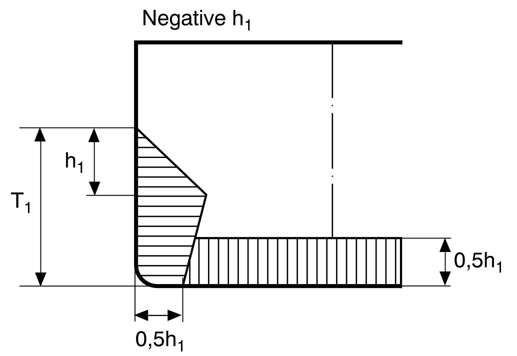


Figure 9 : Wave pressure in upright ship conditions (load cases "a trough")

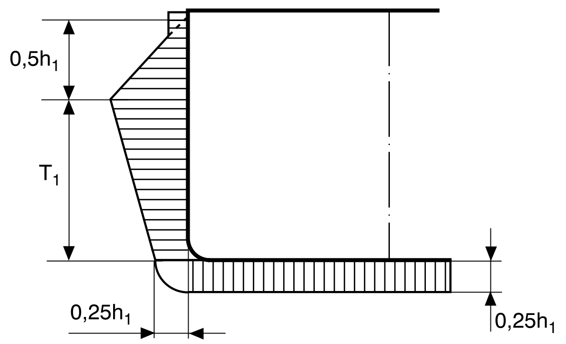


Figure 10 : Wave pressure in upright ship conditions (load case "b")

Table 9 : Wave pressure on sides and bottom in upright ship conditions (load cases "a" and "b")

Location	Wave pressure p_W, in kN/m²	
	Crest	Trough **(1)**
Bottom and sides below the waterline ($z \le T_1$)	$\frac{\rho g C_{F1} h_1}{2}\left(\frac{z+T_1}{T_1}\right)$	$-\frac{\rho g C_{F1} h_1}{2}\left(\frac{z+T_1}{T_1}\right)$ without being taken less than ρ g $(z - T_1)$
Sides above the waterline ($z > T_1$)	ρ g $(T_1 + C_{F1}\ h_1 - z)$ without being taken, for case "a" only, less than 0,24 L	0,0

(1) The wave pressure for load case "b", trough is to be used only for the fatigue check of structural details (see Pt B, Ch 7, Sec 4 of the Ship Rules).

Note 1:

C_{F1} : Combination factor, to be taken equal to:
- C_{F1} = 1,0 for load case "a"
- C_{F1} = 0,5 for load case "b".

Table 10 : Wave pressure on exposed decks in upright ship conditions (load cases "a" and "b")

Location	Wave pressure p_W, in kN/m²	
	Crest	Trough
$0 \le x \le 0{,}5$ L	$28 f_{deck}\varphi_1\varphi_2$	0
0,5 L < x < 0,75 L	$\left\{28+\left[\frac{31{,}3\sqrt{H_F}-28}{0{,}25}\right]\left(\frac{x}{L}-0{,}5\right)\right\}f_{deck}\varphi_1\varphi_2$	0
$0{,}75\ L \le x \le L$	$31{,}3 f_{deck}\varphi_1\varphi_2\sqrt{H}$	0

Note 1:

$$H = C_{F1}\left[2{,}66\left(\frac{x}{L}-0{,}7\right)^2+0{,}14\right]\sqrt{\frac{13L}{C_B}}-(z-T_1)$$ without being taken less than 0,8

f_{deck} : Factor of environment, defined in [3.1], generally taken equal to the values given in Tab 1, according to the severity of the environment and the navigation notation that may be granted to the unit.

φ_1 : Coefficient to be taken equal to 1

φ_2 : Coefficient taken equal to:
- φ_2 = 1 if $L \ge 120$ m
- φ_2 = L/120 if L < 120 m

H_F : Value of H calculated at x = 0,75 L

C_{F1} : Combination factor, to be taken equal to:
- C_{F1} = 1,0 for load case "a"
- C_{F1} = 0,5 for load case "b"

Figure 11 : Wave pressure in inclined ship conditions (load case "c")

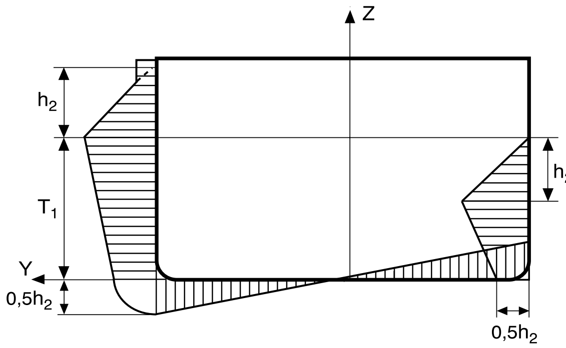
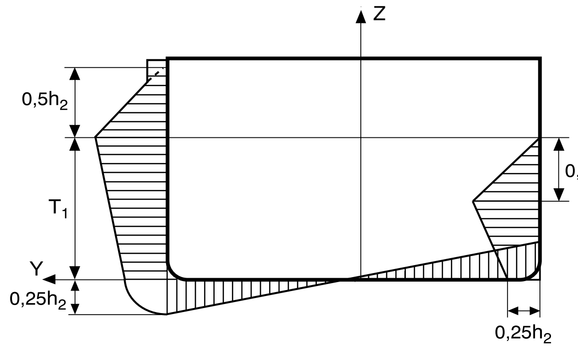


Figure 12 : Wave pressure in inclined ship conditions (load case "d")



5.4 Wave pressure in inclined ship conditions

5.4.1 Pressure on side and bottom

The wave pressure in inclined ship conditions at any point of the hull is obtained from the formulae in Tab 11.

5.4.2 Pressure on exposed decks

The wave pressure on exposed decks is to be considered for load cases "a crest" and "b crest" only (see [5.3.2]).

6 Internal pressures

6.1 Definitions

6.1.1 Cargo

The cargo mass density to be considered is the one indicated on the midship section drawing or in the loading manual.

In the absence of more precise values, a cargo mass density of 0,9 t/m³ is to be considered for calculating the internal pressures.

In case of filling the oil capacities by sea water for towing between yard and site, the density is to be 1,025 t/m³.

6.1.2 Sea water

A sea water mass density of 1,025 t/m³ is to be considered.

6.1.3 Total acceleration vector

The total acceleration vector A_T is the vector whose absolute values of X, Y and Z components are the longitudinal, transverse and vertical accelerations defined in Tab 5 and Tab 6.

In inclined ship conditions:

$$\vec{A_T} = a_{TY2}\vec{Y} + a_{TZ2}\vec{Z}$$

where:

Y, Z : Normed vectors as defined in Fig 13

a_{TY2} , a_{TZ2} : Total accelerations for inclined ship conditions defined in Tab 5 and Tab 6.

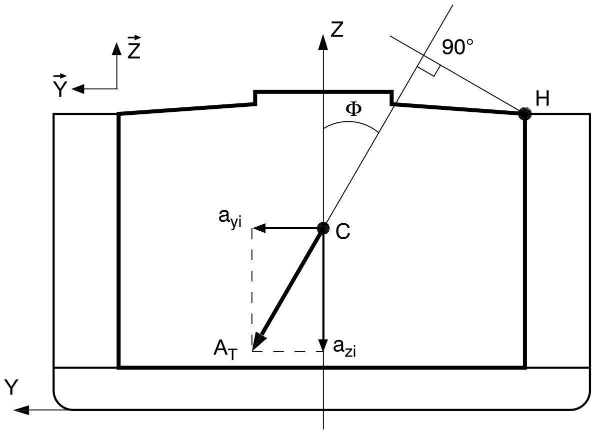
Table 11 : Wave pressure in inclined ship conditions (load cases "c" and "d")

Location	Wave pressure p_W, in kN/m² (negative roll angle)	
	$y \geq 0$	$y < 0$
Bottom and sides below the waterline ($z \leq T_1$)	$\rho g C_{F2} h_2 \frac{y}{B_W}\left[\frac{z + T_1}{T_1}\right]$	$\rho g C_{F2} h_2 \frac{y}{B_W}\left[\frac{z + T_1}{T_1}\right]$ without being taken less than $\rho g (z - T_1)$
Sides above the waterline ($z > T_1$)	$\rho g\left[T_1 + 2\frac{y}{B_W}C_{F2}h_2 - z\right]$ without being taken, for case "c" only, less than 0,15L	0

Note 1:
C_{F2} : Combination factor, to be taken equal to:
- $C_{F2} = 1,0$ for load case "c"
- $C_{F2} = 0,5$ for load case "d"

B_W : Moulded breadth, in m, measured at the waterline at draught T_1, at the hull transverse section considered
A_R : Roll amplitude, defined in [3.3.1].

Figure 13 : Inclined ship conditions Highest point H of the tank in the direction of the total acceleration vector



6.1.4 Highest point of the tank in the direction of the total acceleration vector

The highest point of the tank in the direction of the total acceleration vector A_T, defined in [6.1.3], is the point of the tank boundary whose projection on the direction forming the angle Φ with the vertical direction is located at the greatest distance from the tank's centre of gravity. It is to be determined for the inclined ship conditions, as indicated in Fig 13, where C is the tank's centre of gravity.

6.2 Internal pressures and forces

6.2.1 Internal still water pressure

The still water pressure to be used in combination with the inertial pressure in [6.2.2] is the greater of the values obtained, in kN/m², from the following formulae:

$$p_S = \rho_L\, g\, (z_L - z)$$

$$p_S = \rho_L\, g\, (z_{TOP} - z) + 100\, p_{PV}$$

In no case is it to be taken, in kN/m², less than:

$$p_S = \rho_L g\left(\frac{0,8L_1}{420 - L_1}\right)$$

where:

p_{PV} : Setting pressure, in bar, of safety valves

z_{TOP} : Z co-ordinate, in m, of the highest point of the tank in the z direction

z_L : Z co-ordinate, in m, of the higest point of the liquid:

$$z_L = z_{TOP} + 0,5\,(z_{AP} - z_{TOP})$$

z_{AP} : Z co-ordinate, in m, of the top of the air pipes, to be taken not less than z_{TOP}.

6.2.2 Internal inertial pressure

The inertial pressure is obtained from the formulae in Tab 12 or in Pt B, Ch 5, App 1 of the Ship Rules for typical tank arrangements. In addition, the inertial pressure p_W is to be taken such that:

$$p_S + p_W \geq 0$$

where p_S is defined in [6.2.1].

6.2.3 Pressure for swash bulkheads

The still water and inertial pressures transmitted to the swash bulkhead structures are calculated according to Pt B, Ch 5, Sec 6, [1.2.1] of the Ship Rules.

6.3 Partly filled tanks

6.3.1 General

All capacities are to be checked for several relevant partial filling levels.

A calculation is to be submitted.

6.3.2 Risk of resonance

The risk of resonance and the still water, dynamic sloshing and dynamic impact pressures are to be evaluated according to Pt B, Ch 5, Sec 6, [2] of the Ship Rules.

The values of the pitch period and of the roll period may be taken from the hydrodynamic calculation.

In case of factors of environment greater than 1, no risk of resonance is accepted.

Table 12 : Watertight bulkheads of liquid compartments - Inertial pressure

Ship condition	Load case	Inertial pressure p_W, in kN/m²
Upright	"a"	No inertial pressure
	"b"	$\rho_L[0,5a_{TX1}\ell_B + a_{TZ1}(z_{TOP} - z) + g(z - z_{TOP})]$
Inclined (negative roll angle)	"c"	$0,7\rho_L[a_{TY2}(y - y_H) - a_{TZ2}(z - z_H) + g(z - z_{TOP})]$
	"d"	
Note 1:		
ℓ_B : Longitudinal distance, in m, between the transverse tank boundaries, without taking into account small recesses in the lower part of the tank (see Fig 14)		
y_H, z_H : Y and Z co-ordinates, in m, of the highest point of the tank in the direction of the total acceleration vector, defined in [6.1.3] for load case "c" and load case "d".		

Figure 14 : Upright ship conditions – Distance ℓ_B

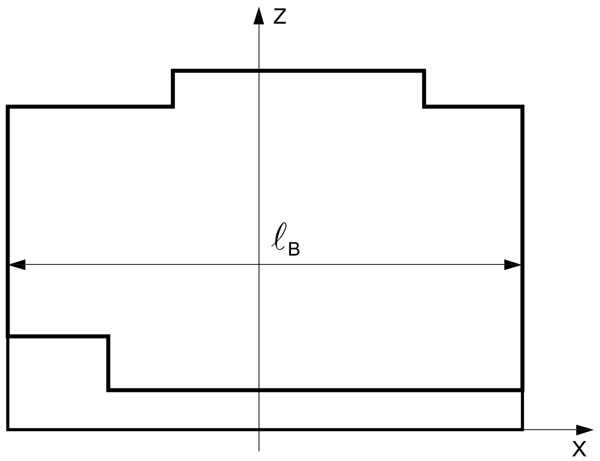


Table 13 : Accommodation
Still water and inertial pressures

Ship condition	Load case	Still water pressure p_S and inertial pressure p_W, in kN/m²
Upright (positive heave motion)	"a"	No inertial pressure
	"b"	$p_W = p_S \frac{\sqrt{a_H^2 + \alpha_P^2 K_X L^2}}{g}$
Inclined	"c"	The inertial pressure transmitted to the deck structures in inclined condition may generally be disregarded. Specific cases in which this simplification is not deemed permissible by the Society are considered individually.
	"d"	

6.3.3 Impact pressure

If there is a risk of resonance, the scantlings are to be verified taking into account pressure given in Pt B, Ch 5, Sec 6, [2] of the Ship Rules.

6.4 Accommodation

6.4.1 Design pressure

The scantlings of the accommodation decks are calculated using a conventional still water and inertial pressure as defined in [6.4.2].

6.4.2 Still water and inertial pressures

The inertial pressures transmitted to the deck structures are obtained, in kN/m², as specified in Tab 13.

The values of p_S depending on the type of the accommodation compartment are given in Pt B, Ch 5, Sec 6, [7] of the Ship Rules.

6.5 Flooding

6.5.1 Still water and inertial pressures

Unless otherwise specified, the still water and inertial pressures to be considered as acting on platings (excluding bottom and side shell platings) which constitute boundaries of compartments not intended to carry liquids, but considered flooded for damaged stability verification, are obtained, in kN/m², from the formulae in Tab 14.

6.6 Testing

6.6.1 Still water pressures

The still water pressure to be considered as acting on plates and stiffeners subject to tank testing is to be obtained from Pt B, Ch 5, Sec 6, [10] of the Ship Rules.

6.6.2 Inertial pressures

The inertial pressures to be considered as acting on plates and stiffeners are given in Pt B, Ch 5, Sec 6, [10] of the Ship Rules.

Table 14 : Flooding
Still water and inertial pressures

Still water pressure p_{SF}, in kN/m²	Inertial pressure p_{WF}, in kN/m²
$\rho g (z_F - z)$ without being taken less than $0,4\ g\ d_0$	$0,6\rho\sqrt{a_H^2 + \alpha_P^2 K_X L^2}(z_F - z)$ without being taken less than $0,4\ g\ d_0$
Note 1: z_F : Z co-ordinate, in m, of the freeboard deck at side in way of the transverse section considered. Where the results of damage stability calculations are available, the deepest equilibrium waterline may be considered in lieu of the freeboard deck; in this case, the Society may require transient conditions to be taken into account d_0 : Distance, in m, to be taken equal to: $d_0 = 0,02\ L$ for $90 \le L \le 120$ $d_0 = 2,4$ for $L \ge 120$	

SECTION 6 HULL GIRDER STRENGTH

1 General

1.1 Principle

1.1.1 The hull girder transverse sections are to comply with Pt B, Ch 6, Sec 1 of the Ship Rules taking into account the requirements of the present Section.

1.1.2 The hull girder strength is to be evaluated independently for the towing phases covered by classification and site conditions.

1.1.3 The hull girder shall be designed to allow flexibility in cargo loading (see Ch 1, Sec 4).

1.2 Strength characteristics of the hull girder transverse sections

1.2.1 The strength characteristics of the hull girder transverse section are to comply with Pt B, Ch 6, Sec 1 of the Ship Rules.

2 Yielding checks

2.1 Hull girder stresses

2.1.1 Normal stresses induced by vertical bending moments

The normal stresses induced by vertical bending moments are obtained, in N/mm², from the following formulae:

- at any point of the hull transverse section:

$$\sigma_1 = \frac{M_{SW} + M_{WV}}{Z_A} 10^3$$

- at bottom:

$$\sigma_1 = \frac{M_{SW} + M_{WV}}{Z_{AB}} 10^3$$

- at deck:

$$\sigma_1 = \frac{M_{SW} + M_{WV}}{Z_{AD}} 10^3$$

where:

Z_A : Gross section modulus, in cm³, at any point of the hull transverse section, to be calculated according to Pt B, Ch 6, Sec 1, [2.3.1] of the Ship Rules

Z_{AB} , Z_{AD} : Gross section moduli, in cm³, at bottom and deck, respectively, to be calculated according to Pt B, Ch 6, Sec 1, [2.3.2] of the Ship Rules.

2.1.2 The normal stresses in a member made in material other than steel with a Young's modulus E equal to 2,06 10^5 N/mm², included in the hull girder transverse sections as specified in Pt B, Ch 6, Sec 1, [2.1.6] of the Ship Rules, are obtained from the following formula:

$$\sigma_1 = \frac{E}{2{,}06 \cdot 10^5} \sigma_{1S}$$

where:

σ_{1S} : Normal stress, in N/mm², in the member under consideration, calculated according to [2.1.1] considering this member as having the steel equivalent sectional area A_{SE} defined in Pt B, Ch 6, Sec 1, [2.1.6] of the Ship Rules.

2.1.3 Shear stress

The shear stresses induced by shear forces are obtained according to Pt B, Ch 6, Sec 2, [2.3] and Pt B, Ch 6, Sec 2, [2.4] of the Ship Rules.

2.2 Checking criteria

2.2.1 Normal stresses induced by vertical bending moments

It is to be checked that the normal stresses σ_1 calculated according to [2.1.1] are in compliance with the following formula:

$$\sigma_1 \le \sigma_{1,ALL}$$

where:

$\sigma_{1,ALL}$: Allowable normal stress, in N/mm², obtained from the following formulae:

$$\sigma_{1,ALL} = \frac{119}{k} \quad \text{for } \frac{x}{L} \le 0{,}1$$

$$\sigma_{1,ALL} = \frac{175}{k} - \frac{1400}{k}\left(\frac{x}{L} - 0{,}3\right)^2 \quad \text{for } 0{,}1 < \frac{x}{L} < 0{,}3$$

$$\sigma_{1,ALL} = \frac{175}{k} \quad \text{for } 0{,}3 \le \frac{x}{L} \le 0{,}7$$

$$\sigma_{1,ALL} = \frac{175}{k} - \frac{1400}{k}\left(\frac{x}{L} - 0{,}7\right)^2 \quad \text{for } 0{,}7 < \frac{x}{L} < 0{,}9$$

$$\sigma_{1,ALL} = \frac{119}{k} \quad \text{for } \frac{x}{L} \ge 0{,}9$$

2.2.2 Shear stresses

It is to be checked that the normal stresses τ_1 calculated according to [2.1.3] are in compliance with the following formula:

$$\tau_1 \le \tau_{1,ALL}$$

where:

$\tau_{1,ALL}$: Allowable shear stress, in N/mm²:

$$\tau_{1,ALL} = 110 / k$$

2.3 Section modulus and moment of inertia

2.3.1 General

The requirements in [2.3] provide the minimum hull girder section modulus, complying with the checking criteria indicated in [2.2], and the midship section moment of inertia required to ensure sufficient hull girder rigidity.

The k material factors are to be defined with respect to the materials used for the bottom and deck members contributing to the longitudinal strength according to [1.2]. When material factors for higher strength steels are used, the requirements in [2.3.5] apply.

2.3.2 Section modulus within 0,4 L amidships

The gross section moduli Z_{AB} and Z_{AD} within 0,4 L amidships are to be not less than the greater value obtained, in m³, from the following formulae:

- $Z_{R,MIN} = n_1\ C\ L^2\ B\ (C_B + 0{,}7)\ k\ 10^{-6}$
- $Z_R = \dfrac{M_{SW} + M_{WV1}}{\sigma_{1,ALL}} 10^{-3}$

where:

n_1 : Coefficient given in Tab 1.

Table 1 : Navigation coefficient n_1

Navigation notation	Navigation coefficient n_1
Unrestricted navigation	1,00
Summer zone	0,95
Tropical zone	0,90
Coastal area	0,90
Sheltered area	0,80
Note 1: For units operating in harsh environment (i.e. factors of environment greater than 1), n_1 may be taken greater than 1. In this case, the determination of n_1 is specially considered by the Society.	

For units operating in benign areas, $Z_{R,min}$ may be reduced but not more than 20%.

Where the total breadth Σb_S of small openings, as defined in Pt B, Ch 6, Sec 1 of the Ship Rules, is deducted from the sectional areas included in the hull girder transverse sections, the values Z_R and $Z_{R,MIN}$ may be reduced by 3%.

Scantlings of members contributing to the longitudinal strength (see Pt B, Ch 6, Sec 1 of the Ship Rules) are to be maintained within 0,4 L amidships.

2.3.3 Section modulus outside 0,4 L amidships

The gross section moduli Z_{AB} and Z_{AD} outside 0,4 L amidships are to be not less than the value obtained, in m³, from the following formula:

$$Z_R = \frac{M_{SW} + M_{WV}}{\sigma_{1,ALL}} 10^{-3}$$

Scantlings of members contributing to the hull girder longitudinal strength (see Pt B, Ch 6, Sec 1 of the Ship Rules) may be gradually reduced, outside 0,4 L amidships, to the minimum required for local strength purposes at fore and aft parts, as specified in Part B, Chapter 9 of the Ship Rules.

2.3.4 Midship section moment of inertia

The gross midship section moment of inertia about its horizontal neutral axis is to be not less than the value obtained, in m⁴, from the following formula:

$$I_{YR} = 3\ Z'_{R,MIN}\ L\ 10^{-2}$$

where $Z'_{R,MIN}$ is the required midship section modulus $Z_{R,MIN}$, in m³, calculated as specified in [2.3.2], but assuming k = 1.

2.3.5 Extent of higher strength steel

When a material factor for higher strength steel is used in calculating the required section modulus at bottom or deck according to [2.3.2] or [2.3.3], the relevant higher strength steel is to be adopted for the members contributing to the longitudinal strength (see Pt B, Ch 6, Sec 1 of the Ship Rules), at least up to a vertical distance, in m, obtained from the following formulae:

- above the baseline (for section modulus at bottom):

$$V_{HB} = \frac{\sigma_{1B} - k\sigma_{1,ALL}}{\sigma_{1B} + \sigma_{1D}} z_D$$

- below a horizontal line located at a distance V_D (see Pt B, Ch 6, Sec 1 of the Ship Rules) above the neutral axis of the hull transverse section (for section modulus at deck):

$$V_{HD} = \frac{\sigma_{1D} - k\sigma_{1,ALL}}{\sigma_{1B} + \sigma_{1D}} (N + V_D)$$

where:

σ_{1B}, σ_{1D} : Normal stresses, in N/mm², at bottom and deck, respectively, calculated according to [2.1.1]

z_D : Z co-ordinate, in m, of the strength deck, defined in Pt B, Ch 6, Sec 1 of the Ship Rules, with respect to the reference co-ordinate system defined in Ch 1, Sec 1, [4.3]

N : Z co-ordinate, in m, of the centre of gravity of the hull transverse section defined in Pt B, Ch 6, Sec 1 of the Ship Rules, with respect to the reference co-ordinate system defined in Ch 1, Sec 1, [4.3]

V_D : Vertical distance, in m, defined in Pt B, Ch 6, Sec 1 of the Ship Rules.

The higher strength steel is to extend in length at least throughout 0,4 L amidships where it is required for strength purposes according to the requirements of Part B of the Ship Rules.

3 Ultimate strength check

3.1 General

3.1.1 The ultimate strength of the hull girder is to be checked according on Pt B, Ch 6, Sec 3 and Pt B, Ch 6, App 1 of the Ship Rules.

The check is to be done on net scantlings.

The partial safety factors to be taken into account are those given in [3.2].

3.2 Partial safety factors

3.2.1 The safety factors to be taken into account in the ultimate strength check of the hull girder are those given in Tab 2.

Table 2 : Partial safety factors

Partial safety factor covering uncertainties on:	Symbol	Value
Still water hull girder loads	γ_{S1}	1,00
Wave induced hull girder loads	γ_{W1}	1,10
Material	γ_m	1,02
Resistance	γ_R	1,20

3.3 Hull girder loads

3.3.1 Bending moment in operation

The bending moment in operation, in sagging and hogging conditions, to be considered in the ultimate strength check of the hull girder, is to be obtained, in kN.m, from the following formula:

$$M = \gamma_{S1}\, M_{SW} + \gamma_{W1}\, M_{WV}$$

3.4 Hull girder ultimate bending moment capacities

3.4.1 The hull girder ultimate bending moment capacities are to be determined according to Pt B, Ch 6, Sec 3, [3.2] and Pt B, Ch 6, App 1 of the Ship Rules.

3.5 Checking criteria

3.5.1 It is to be checked that the hull girder ultimate bending capacity at any hull transverse section is in compliance with the following formula:

$$\frac{M_U}{\gamma_R \gamma_M} \geq M$$

SECTION 7 HULL SCANTLINGS

Symbols

$M_{SW,H}$: Design still water bending moment, in kN.m, in hogging condition, at the hull transverse section considered, defined in Ch 1, Sec 5, [2.2.1]

$M_{SW,S}$: Design still water bending moment, in kN.m, in sagging condition, at the hull transverse section considered, defined in Ch 1, Sec 5, [2.2.1]

$M_{WV,H}$: Vertical wave bending moment, in kN.m, in hogging condition, at the hull transverse section considered, defined in Ch 1, Sec 5, [3.2.1]

$M_{WV,S}$: Vertical wave bending moment, in kN.m, in sagging condition, at the hull transverse section considered, defined in Ch 1, Sec 5, [3.2.1]

M_{WH} : Horizontal wave bending moment, in kN.m, at the hull transverse section considered, defined in Ch 1, Sec 5, [3.2.2]

N : Z co-ordinate, in m, with respect to the reference co-ordinate system (defined in Ch 1, Sec 1, [4.3]) of the centre of gravity of the hull transverse section constituted by members contributing to the hull girder longitudinal strength considered as having their net scantlings

x, y, z : X, Y and Z co-ordinates, in m, of the calculation point with respect to the reference co-ordinate system defined in Ch 1, Sec 1, [4.3]

I_Y : Net moment of inertia, in m^4, of the hull transverse section around its horizontal neutral axis, to be calculated according to Ch 1, Sec 6, [1.2] considering the members contributing to the hull girder longitudinal strength as having their net scantlings

I_Z : Net moment of inertia, in m^4, of the hull transverse section around its vertical neutral axis, to be calculated according to Ch 1, Sec 6, [1.2] considering the members contributing to the hull girder longitudinal strength as having their net scantlings

k : Material factor for steel defined in Pt B, Ch 4, Sec 1 of the Ship Rules

R_y : Minimum yield stress, in N/mm^2, of the material, to be taken equal to 235/k unless otherwise specified

s : Spacing, in m, of ordinary stiffeners

ℓ : Span, in m, of ordinary stiffeners, measured between supporting members (see Pt B, Ch 4, Sec 3, [3.2] of the Ship Rules

p_S : Static pressure, in kN/m^2, as defined in Ch 1, Sec 5

p_W : Inertial pressure, in kN/m^2, as defined in Ch 1, Sec 5

L, L_1, B, D: Unit's dimensions defined in Ch 1, Sec 5.

1 General

1.1 Principle

1.1.1 Plating, ordinary stiffeners and primary supporting members are to comply with the requirements of Part B, Chapter 7 and Part D, Chapter 7 of the Ship Rules, taking into account the requirements of the present Section.

In case of conflict between the Ship Rules and the present Chapter, this latter is to take precedence.

1.2 Net thickness

1.2.1 All thickness referred to in this Section are net, i.e. they do not include any margin for corrosion.

The gross thickness are obtained as specified in Ch 1, Sec 3.

1.3 Partial safety factors

1.3.1 The partial safety factors to be considered for the determination of the rule scantlings are specified in the present Section.

2 Plating

2.1 General

2.1.1 Principle

The thickness plating is to be calculated according to Pt B, Ch 7, Sec 1 and Part D, Chapter 7 of the Ship Rules taking into account the requirements of the present [2].

2.1.2 Partial safety factors

The partial safety factors to be used for the assessment of scantlings of plating are given in Tab 1.

Table 1 : Plating - Partial safety factors

Partial safety factors covering uncertainties regarding:	Symbol	Strength check of plating subjected to lateral pressure					Buckling check
		General	Sloshing pressure	Impact pressure	Watertight bulkhead plating **(1)**	Testing check	
Still water hull girder loads	γ_{S1}	1,00	0	0	1,00	N.A.	1,00
Wave hull girder loads	γ_{W1}	1,07	0	0	1,07	N.A.	1,07
Still water pressure	γ_{S2}	1,00	1,00	1,00	1,00	1,00	N.A.
Wave pressure	γ_{W2}	1,07	1,05	1,20	1,07	N.A.	N.A.
Material	γ_m	1,02	1,02	1,02	1,02	1,02	1,02
Resistance	γ_R	1,02	1,10	1,02	1,02 **(2)**	1,05	1,02

(1) Applies also to plating of bulkheads or inner side which constitute boundary of compartments not intended to carry liquids.
(2) For plating of the collision bulkhead, γ_R =1,25
Note 1: N.A. = not applicable.

Table 2 : Hull girder normal stresses

Condition	σ_{S1}, in N/mm² **(1)**	σ_{WV1}, in N/mm²	σ_{WH1}, in N/mm²
$\frac{\lvert\gamma_{S1}M_{SW,S}+\gamma_{W1}M_{WV,S}\rvert}{\gamma_{S1}M_{SW,H}+\gamma_{W1}M_{WV,H}} \geq 1$	$\left\lvert\frac{M_{SW,S}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV,S}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WH}}{I_Z}y\right\rvert 10^{-3}$
$\frac{\lvert\gamma_{S1}M_{SW,S}+\gamma_{W1}M_{WV,S}\rvert}{\gamma_{S1}M_{SW,H}+\gamma_{W1}M_{WV,H}} < 1$	$\left\lvert\frac{M_{SW,H}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV,H}}{I_Y}(z-N)\right\rvert 10^{-3}$	

(1) When the ship in still water is always in hogging condition, $M_{SW,S}$ is to be taken equal to 0.

2.2 Yielding check

2.2.1 In-plane hull girder normal stresses

The in-plane hull girder normal stresses to be considered for the strength check of plating in upright ship conditions are obtained, in N/mm², from the following formulae:

- for plating not contributing to the hull girder longitudinal strength:

  $\sigma_{X1} = 0$

- for plating contributing to the hull girder longitudinal strength:

$$\sigma_{X1} = \gamma_{S1}\sigma_{S1} + \gamma_{W1}(C_{FV}\sigma_{WV1} + C_{FH}\sigma_{WH})$$

where:

σ_{S1}, σ_{WV1}: Hull girder normal stresses, in N/mm², defined in Tab 2

C_{FV}, C_{FH} : Combination factors given in Tab 3.

2.2.2 In-plane hull girder shear stresses

The in-plane hull girder shear stresses to be considered for the strength check of plating, subjected to lateral loads, which contributes to the longitudinal strength are obtained, in N/mm², from the following formula:

$\tau_1 = \gamma_{S1}\ \tau_{S1} + C_{FV}\ \gamma_{w1}\ \tau_{w1}$

where:

τ_{S1} : Absolute value of the hull girder shear stresses, in N/mm², induced by the maximum still water hull girder vertical shear force in the section considered

Table 3 : Combination factor C_{FV} and C_{FH} for plating

Load case	C_{FV}	C_{FH}
"a"	1,0	0
"b"	0,7	0
"c"	0,4	1,0
"d"	0,25	0,7

Table 4 : Hull girder shear stresses

Structural element	τ_{S1}, τ_{W1} in N/mm²
Bottom, inner bottom and decks (excluding possible longitudinal sloping plates)	0
Bilge, side, inner side and longitudinal bulkheads (including possible longitudinal sloping plates):	
• $0 \leq z \leq 0,25\ D$	$\tau_0\left(0,5 + 2\frac{z}{D}\right)$
• $0,25\ D < z \leq 0,75\ D$	τ_0
• $0,75\ D < z \leq D$	$\tau_0\left(2,5 - 2\frac{z}{D}\right)$

Note 1:

$$\tau_0 = \frac{47}{k}\left\{1 - \frac{6,3}{\sqrt{L_1}}\right\} \text{ N/mm}^2$$

τ_{W1} : Absolute value of the hull girder shear stresses, in N/mm², induced by the maximum wave hull girder vertical shear force in the section considered

C_{FV} : Combination factor given in Tab 3.

τ_{S1} and τ_{W1} are to be taken not less than the values indicated in Tab 4.

2.3 Buckling check

2.3.1 General

The buckling check of plating is to be performed in accordance with Pt B, Ch 7, Sec 1, [5] of the Ship Rules.

However the compression stresses to be taken into account for the checking criteria given in Pt B, Ch 7, Sec 1, [5.4] of the Ship Rules are given as follows:

a) Compression and bending

   The compression stress σ_b, in N/mm², acting on side "b" of the plate panel, is to be calculated as specified in [2.3.2] or [2.3.4].

b) Shear

   The shear stress, in N/mm², acting on the plate panel is to be calculated as specified in [2.3.3] or [2.3.5].

c) Compression, bending and shear

   The compression stresses σ_1 and σ_2, in N/mm², defined in Pt B, Ch 7, Sec 1, Fig 2 of the Ship Rules are to be calculated as specified in [2.3.2] or [2.3.4].

   The shear stress τ, in N/mm², is to be calculated as specifiec in [2.3.3] or [2.3.5].

d) Bi-axial compression, taking account of shear stress

   The compression stresses σ_a and σ_b, in N/mm², are to be calculated as specified in [2.3.2] or [2.3.4].

   The shear stress τ, in N/mm², is to be calculated as specified in [2.3.3] or [2.3.5].

2.3.2 In-plane hull girder compression normal stresses

The in-plane hull girder compression normal stresses to be considered for the buckling check of plating contributing to the longitudinal strength in inclined ship conditions are obtained, in N/mm², from the following formula:

$$\sigma_{X1} = \gamma_{S1}\sigma_{S1} + \gamma_{w1}(C_{FV}\sigma_{WV1} + C_{FH}\sigma_{WH})$$

where:

σ_{S1}, σ_{WV1}, σ_{WH} : Hull girder normal stresses, in N/mm², defined in Tab 5

C_{FV}, C_{FH} : Combination factors defined in Tab 3.

σ_{X1} is to be taken as the maximum compression stress on the plate panel considered.

In no case may σ_{X1} be taken less than 30/k N/mm².

When the ship in still water is always in hogging condition, σ_{X2} may be evaluated by means of direct calculations when justified on the basis of the ship's characteristics and intended service. The calculations are to be submitted to the Society for approval.

2.3.3 In-plane hull girder shear stresses

The in-plane hull girder shear stresses to be considered for the buckling check of plating are obtained as specified in [2.2.2]for the strength check of plating subjected to lateral pressure, which contributes to the longitudinal strength.

2.3.4 Combined in-plane hull girder and local compression normal stresses

The combined in-plane compression normal stresses to be considered for the buckling check of plating are to take into account the hull girder stresses and the local stresses resulting from the bending of the primary supporting members. These local stresses are to be obtained from a direct structural analysis using the design loads given in Ch 1, Sec 4.

With respect to the reference co-ordinate system defined in Pt B, Ch 1, Sec 2 of the Ship Rules, the combined stresses in x and y direction are obtained, in N/mm², from the following formulae:

$$\sigma_X = \sigma_{X1} + \gamma_{S2}\sigma_{X2,S} + \gamma_{W2}\sigma_{X2,W}$$

$$\sigma_Y = \gamma_{S2}\sigma_{Y2,S} + \gamma_{W2}\sigma_{Y2,W}$$

where:

σ_{X1} : Compression normal stress, in N/mm², induced by the hull girder still water and wave loads, defined in [2.2.1] or [2.3.2].

$\sigma_{X2,S}$,$\sigma_{Y2,S}$: Compression normal stress in x and y direction, respectively, in N/mm², induced by the local bending of the primary supporting members and obtained from a direct structural analysis using the still water design loads given in Ch 1, Sec 4

Table 5 : Hull girder normal compression stresses for buckling check of plates

Condition	σ_{S1} in N/mm² **(1)**	σ_{WV1} in N/mm²	σ_{WH} in N/mm²
$z \geq N$	$\frac{M_{SW,S}}{I_Y}(z-N)10^{-3}$	$\frac{M_{WV,S}}{I_Y}(z-N)10^{-3}$	$-\left\lvert\frac{M_{WH}}{I_Z}y\right\rvert 10^{-3}$
$z < N$	$\frac{M_{SW,H}}{I_Y}(z-N)10^{-3}$	$\frac{M_{WV,H}}{I_Y}(z-N)10^{-3}$	

(1) When the ship in still water is always in hogging condition, σ_{S2} for $z \geq N$ is to be obtained, in N/mm², from the following formula, unless σ_{X1} is evaluated by means of direct calculations (see [2.3.2]):

$$\sigma_{S2} = \frac{M_{SW,Hmin}}{I_Y}(z-N)10^{-3}$$

$\sigma_{X2,W}$, $\sigma_{Y2,W}$: Compression normal stress in x and y direction, respectively, in N/mm², induced by the local bending of the primary supporting members and obtained from a direct structural analysis using the wave design loads given in Ch 1, Sec 4.

2.3.5 Combined in-plane hull girder and local shear stresses

The combined in-plane shear stresses to be considered for the buckling check of plating are to take into account the hull girder stresses and the local stresses resulting from the bending of the primary supporting members. These local stresses are to be obtained from a direct structural analysis using the design loads given in Ch 1, Sec 4.

The combined stresses are obtained, in N/mm², from the following formula:

$$\tau = \tau_1 + \gamma_{S2}\,\tau_{2,S} + \gamma_{W2}\,\tau_{2,W}$$

where:

τ_1 : Shear stress, in N/mm², induced by the hull girder still water and wave loads, defined in [2.2.2]

$\tau_{2,S}$: Shear stress, in N/mm², induced by the local bending of the primary supporting members and obtained from a direct structural analysis using the still water design loads given in Ch 1, Sec 4

$\tau_{2,W}$: Shear stress, in N/mm², induced by the local bending of the primary supporting members and obtained from a direct structural analysis using the wave design loads given in Ch 1, Sec 4.

3 Yielding check of ordinary stiffeners

3.1 General

3.1.1 Principle

The scantlings are to be in accordance with Pt B, Ch 7, Sec 2 and Part D, Chapter 7 of the Ship Rules taking into account the requirements of the present Section.

3.1.2 Partial safety factors

The partial safety factors to be considered for the yielding check of ordinary stiffeners are specified in Tab 6.

3.2 Hull girder stresses

3.2.1 The hull girder normal stresses to be considered for the yielding check of ordinary stiffeners are obtained, in N/mm², from the following formulae:

- for longitudinal stiffeners contributing to the hull girder longitudinal strength and subjected to lateral pressure:

  $\sigma_{X1} = \gamma_{S1}\,\sigma_{S1} + \gamma_{W1}\,(C_{FV}\,\sigma_{WV1} + C_{FH}\,\sigma_{WH})$

  to be taken not less than 75 / k
- for longitudinal stiffeners not contributing to the hull girder longitudinal strength:

  $\sigma_{X1} = 0$
- for transverse stiffeners:

  $\sigma_{X1} = 0$

where:

σ_{S1}, σ_{WV1}, σ_{WH} : Hull girder normal stresses, in N/mm², defined in Tab 7

C_{FV}, C_{FH} : Combination factors given in Tab 8.

3.3 Net section modulus and net shear sectional area of ordinary stiffeners in intact conditions

3.3.1 Groups of equal ordinary stiffeners

Where a group of equal ordinary stiffeners is fitted, it is acceptable that the minimum net section modulus given in [3.3.2] to [3.3.4] is calculated as the average of the values required for all the stiffeners of the same group, but this average is to be taken not less than 90% of the maximum required value.

The same applies for the minimum net shear sectional area.

Table 6 : Ordinary stiffeners - Partial safety factors

Partial safety factors covering uncertainties regarding:	Symbol	Yielding check					Buckling check	Ultimate strength check
		General	Sloshing pressure	Impact pressure	Watertight bulkhead ordinary stiffeners **(1)**	Testing check		
Still water hull girder loads	γ_{S1}	1,00	0	0	1,00	N.A.	1,00	1,00
Wave hull girder loads	γ_{W1}	1,07	0	0	1,07	N.A.	1,07	1,10
Still water pressure	γ_{S2}	1,00	1,00	1,00	1,00	1,00	N.A.	1,00
Wave pressure	γ_{W2}	1,07	1,10	1,00	1,05	N.A.	N.A.	1,15
Material	γ_m	1,02	1,02	1,02	1,02	1,02	1,02	1,02
Resistance	γ_R	1,02	1,02	1,02	1,02 **(2)**	1,20	1,02	1,02

(1) Applies also to ordinary stiffeners of bulkheads or inner side which constitute boundary of compartments not intended to carry liquids.
(2) For ordinary stiffeners of the collision bulkhead, γ_R =1,25.
Note 1: N.A. = Not applicable.

Table 7 : Hull girder normal stresses - Ordinary stiffeners subjected to lateral pressure

Condition	σ_{S1} , in N/mm² **(1)**	σ_{WV1} , in N/mm²	σ_{WH} , in N/mm²
Lateral pressure applied on the side opposite to the ordinary stiffener, with respect to the plating:			$\left\lvert\frac{M_{WH}}{I_Z}y\right\rvert 10^{-3}$
• z ≥ N	$\left\lvert\frac{M_{SW,S}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV,S}}{I_Y}(z-N)\right\rvert 10^{-3}$	
• z < N	$\left\lvert\frac{M_{SW,H}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV,H}}{I_Y}(z-N)\right\rvert 10^{-3}$	
Lateral pressure applied on the same side as the ordinary stiffener:			
• z ≥ N	$\left\lvert\frac{M_{SW,H}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV,H}}{I_Y}(z-N)\right\rvert 10^{-3}$	
• z < N	$\left\lvert\frac{M_{SW,S}}{I_Y}(z-N)\right\rvert 10^{-3}$	$\left\lvert\frac{M_{WV,S}}{I_Y}(z-N)\right\rvert 10^{-3}$	
(1) When the ship in still water is always in hogging condition, $M_{SW,S}$ is to be taken equal to 0.			

Table 8 : Combination factor C_{FV} and C_{FH} for stiffeners

Load case	C_{FV}	C_{FH}
"a"	1,0	0
"b"	0,7	0
"c"	0,4	1,0
"d"	0,25	0,7

3.3.2 Single span longitudinal and transverse ordinary stiffeners subjected to lateral pressure

The net section modulus w, in cm³, and the net shear sectional area A_{Sh} , in cm², of longitudinal or transverse ordinary stiffeners subjected to lateral pressure are to be not less than the values obtained from the following formulae:

$$w = \gamma_R\gamma_m\beta_b\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{12(R_y-\gamma_R\gamma_m\alpha_S\sigma_{X1})}\left(1-\frac{s}{2\ell}\right)s\ell^2 10^3$$

$$A_{Sh} = 10\gamma_R\gamma_m\beta_s\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{R_y}\left(1-\frac{s}{2\ell}\right)s\ell$$

where:

β_b, β_s : Coefficients defined in Tab 9

α_S : Coefficient to be taken equal to 0,9.

3.3.3 Single span vertical ordinary stiffeners subjected to lateral pressure

The net section modulus w, in cm³, and the net shear sectional area A_{Sh} , in cm², of vertical ordinary stiffeners subjected to lateral pressure are to be not less than the values obtained from the following formulae:

$$w = \gamma_R\gamma_m\lambda_b\beta_b\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{12R_y}\left(1-\frac{s}{2\ell}\right)s\ell^2 10^3$$

$$A_{Sh} = 10\gamma_R\gamma_m\lambda_s\beta_s\frac{\gamma_{S2}p_S+\gamma_{W2}p_W}{R_y}\left(1-\frac{s}{2\ell}\right)s\ell$$

where:

Table 9 : Coefficients β_b and β_s

Brackets at ends	Bracket lengths	β_b	β_s
0	–	1	1
1	ℓ_b	$\left(1-\frac{\ell_b}{2\ell}\right)^2$	$1-\frac{\ell_b}{2\ell}$
2	ℓ_{b1} ; ℓ_{b2}	$\left(1-\frac{\ell_{b1}}{2\ell}-\frac{\ell_{b2}}{2\ell}\right)^2$	$1-\frac{\ell_{b1}}{2\ell}-\frac{\ell_{b2}}{2\ell}$
Note 1: The bracket length ℓ_b is defined in Pt B, Ch 4, Sec 3 of the Ship Rules. ℓ_{b1} and ℓ_{b2} are the lengths of the two brackets fitted at each end.			

β_b, β_s : Coefficients defined in Tab 9

λ_b : Coefficient taken equal to the greater of the following values:

$$\lambda_b = 1+0,2\frac{\gamma_{S2}(p_{Sd}-p_{Su})+\gamma_{W2}(p_{Wd}-p_{Wu})}{\gamma_{S2}(p_{Sd}+p_{Su})+\gamma_{W2}(p_{Wd}+p_{Wu})}$$

$$\lambda_b = 1-0,2\frac{\gamma_{S2}(p_{Sd}-p_{Su})+\gamma_{W2}(p_{Wd}-p_{Wu})}{\gamma_{S2}(p_{Sd}+p_{Su})+\gamma_{W2}(p_{Wd}+p_{Wu})}$$

λ_s : Coefficient taken equal to the greater of the following values:

$$\lambda_s = 1+0,4\frac{\gamma_{S2}(p_{Sd}-p_{Su})+\gamma_{W2}(p_{Wd}-p_{Wu})}{\gamma_{S2}(p_{Sd}+p_{Su})+\gamma_{W2}(p_{Wd}+p_{Wu})}$$

$$\lambda_s = 1-0,4\frac{\gamma_{S2}(p_{Sd}-p_{Su})+\gamma_{W2}(p_{Wd}-p_{Wu})}{\gamma_{S2}(p_{Sd}+p_{Su})+\gamma_{W2}(p_{Wd}+p_{Wu})}$$

p_{Sd} : Still water pressure, in kN/m², at the lower end of the ordinary stiffener considered

p_{Su} : Still water pressure, in kN/m², at the upper end of the ordinary stiffener considered

p_{Wd} : Wave pressure, in kN/m², at the lower end of the ordinary stiffener considered

p_{Wu} : Wave pressure, in kN/m², at the upper end of the ordinary stiffener considered.

3.3.4 Multispan ordinary stiffeners

The maximum normal stress σ and shear stress τ in a multispan ordinary stiffener are to be determined by a direct calculation taking into account:

- the distribution of still water and wave pressure and forces, to be determined on the basis of the criteria specified in Ch 1, Sec 4
- the number and position of intermediate supports (decks, girders, etc.)
- the condition of fixity at the ends of the stiffener and at intermediate supports
- the geometrical characteristics of the stiffener on the intermediate spans.

The maximum normal stress σ and shear stress τ in a multispan ordinary stiffener are to comply with the following formulae:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma$$

$$0{,}5\frac{R_y}{\gamma_R \gamma_m} \geq \tau$$

3.4 Net section modulus and net shear sectional area of ordinary stiffeners in flooding conditions

3.4.1 Groups of equal ordinary stiffeners

Where a group of equal ordinary stiffeners is fitted, it is acceptable that the minimum net section modulus given in [3.4.2] to [3.4.4] is calculated as the average of the values required for all the stiffeners of the same group, but this average is to be taken not less than 90% of the maximum required value.

The same applies for the minimum net shear sectional area.

3.4.2 Single span longitudinal and transverse ordinary stiffeners

The net section modulus w, in cm^3, and the net shear sectional area A_{Sh}, in cm^2, of longitudinal or transverse ordinary stiffeners are to be not less than the values obtained from the following formulae:

$$w = \gamma_R \gamma_m \beta_b \frac{\gamma_{S2} p_{SF} + \gamma_{W2} p_{WF}}{12(R_y - \gamma_R \gamma_m \alpha_S \sigma_{X1})}\left(1 - \frac{s}{2\ell}\right) s \ell^2 10^3$$

$$A_{Sh} = 10 \gamma_R \gamma_m \beta_s \frac{\gamma_{S2} p_{SF} + \gamma_{W2} p_{WF}}{R_y}\left(1 - \frac{s}{2\ell}\right) s \ell$$

where:

β_b, β_s : Coefficients defined in Tab 9

α_S : Coefficient to be taken equal to 0,9.

3.4.3 Single span vertical ordinary stiffeners

The net section modulus w, in cm^3, and the net shear sectional area A_{Sh}, in cm^2, of vertical ordinary stiffeners are to be not less than the values obtained from the following formulae:

$$w = \gamma_R \gamma_m \lambda_b \beta_b \frac{\gamma_{S2} p_{SF} + \gamma_{W2} p_{WF}}{12 R_y}\left(1 - \frac{s}{2\ell}\right) s \ell^2 10^3$$

$$A_{Sh} = 10 \gamma_R \gamma_m \lambda_s \beta_s \frac{\gamma_{S2} p_{SF} + \gamma_{W2} p_{WF}}{R_y}\left(1 - \frac{s}{2\ell}\right) s \ell$$

where:

β_b, β_s : Coefficients defined in Tab 9

λ_b : Coefficient taken equal to the greater of the following values:

$$\lambda_b = 1 + 0{,}2\frac{\gamma_{S2}(p_{SFd} - p_{SFu}) + \gamma_{W2}(p_{WFd} - p_{WFu})}{\gamma_{S2}(p_{SFd} + p_{SFu}) + \gamma_{W2}(p_{WFd} + p_{WFu})}$$

$$\lambda_b = 1 - 0{,}2\frac{\gamma_{S2}(p_{SFd} - p_{SFu}) + \gamma_{W2}(p_{WFd} - p_{WFu})}{\gamma_{S2}(p_{SFd} + p_{SFu}) + \gamma_{W2}(p_{WFd} + p_{WFu})}$$

λ_s : Coefficient taken equal to the greater of the following values:

$$\lambda_s = 1 + 0{,}4\frac{\gamma_{S2}(p_{SFd} - p_{SFu}) + \gamma_{W2}(p_{WFd} - p_{WFu})}{\gamma_{S2}(p_{SFd} + p_{SFu}) + \gamma_{W2}(p_{WFd} + p_{WFu})}$$

$$\lambda_s = 1 - 0{,}4\frac{\gamma_{S2}(p_{SFd} - p_{SFu}) + \gamma_{W2}(p_{WFd} - p_{WFu})}{\gamma_{S2}(p_{SFd} + p_{SFu}) + \gamma_{W2}(p_{WFd} + p_{WFu})}$$

p_{SFd} : Still water pressure, in kN/m^2, in flooding conditions, at the lower end of the ordinary stiffener considered (see Ch 1, Sec 5, [6.5])

p_{SFu} : Still water pressure, in kN/m^2, in flooding conditions, at the upper end of the ordinary stiffener considered (see Ch 1, Sec 5, [6.5])

p_{WFd} : Wave pressure, in kN/m^2, in flooding conditions, at the lower end of the ordinary stiffener considered (see Ch 1, Sec 5, [6.5])

p_{WFu} : Wave pressure, in kN/m^2, in flooding conditions, at the upper end of the ordinary stiffener considered (see Ch 1, Sec 5, [6.5]).

3.4.4 Multispan ordinary stiffeners

The maximum normal stress σ and shear stress τ in a multispan ordinary stiffener in flooding conditions are to be determined by a direct calculation taking into account:

- the distribution of still water and wave pressure and forces in flooding conditions, to be determined on the basis of the criteria specified in Ch 1, Sec 4
- the number and position of intermediate supports (decks, girders, etc.)
- the condition of fixity at the ends of the stiffener and at intermediate supports
- the geometrical characteristics of the stiffener on the intermediate spans.

The maximum normal stress σ and shear stress τ in a multispan ordinary stiffener are to comply with the following formulae:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma$$

$$0{,}5\frac{R_y}{\gamma_R \gamma_m} \geq \tau$$

3.5 Net section modulus and net shear sectional area of ordinary stiffeners in testing conditions

3.5.1 The net section modulus and net shear sectional area of ordinary stiffeners in testing conditions are to comply with the requirements of Pt B, Ch 7, Sec 2, [3.9] of the Ship Rules.

Table 10 : Hull girder normal compression stresses for buckling check

Condition	σ_{S1} in N/mm² **(1)**	σ_{WV1} in N/mm²	σ_{WH} in N/mm²
$z \geq N$	$\frac{M_{SW,S}}{I_Y}(z-N)10^{-3}$	$\frac{M_{WV,S}}{I_Y}(z-N)10^{-3}$	$-\left\vert\frac{M_{WH}}{I_Z}y\right\vert 10^{-3}$
$z < N$	$\frac{M_{SW,H}}{I_Y}(z-N)10^{-3}$	$\frac{M_{WV,H}}{I_Y}(z-N)10^{-3}$	

(1) When the ship in still water is always in hogging condition, σ_{S1} for $z \geq N$ is to be obtained, in N/mm², from the following formula, unless σ_{X1} is evaluated by means of direct calculations:

$$\sigma_{S1} = \frac{M_{SW,Hmin}}{I_Y}(z-N)10^{-3}$$

4 Buckling and ultimate strength check of ordinary stiffeners

4.1 Buckling check

4.1.1 General

The buckling check of plating is to be performed in accordance with Pt B, Ch 7, Sec 2, [4] of the Ship Rules.

However the compression stresses to be taken into account for the checking criteria are given as follows:

a) Stiffeners parallel to the direction of compression

The compression stresses σ_{xb} or σ_{yb}, in N/mm², in the stiffener is to be calculated according to [4.1.2] and [4.1.3].

b) Stiffeners perpendicular to the direction of compression

The compression stress σ, in N/mm², in the stiffener is to be calculated according to [4.1.2] and [4.1.3].

4.1.2 Hull girder compression normal stresses

The hull girder compression normal stresses to be considered in inclined ship conditions for the buckling check of ordinary stiffeners contributing to the hull girder longitudinal strength are obtained, in N/mm², from the following formula:

$$\sigma_{X1} = \gamma_{S1}\,\sigma_{S1} + \gamma_{W1}\,(C_{FV}\,\sigma_{WV1} + C_{FH}\,\sigma_{WH})$$

where:

σ_{S1}, σ_{WV1}, σ_{WH} : Hull girder normal stresses, in N/mm², defined in Tab 10.

For longitudinal stiffeners, σ_{X1} is to be taken as the maximum compression stress on the stiffener considered.

In no case may σ_{X1} be taken less than 30/ k N/mm².

When the ship in still water is always in hogging condition, σ_{X1} may be evaluated by means of direct calculations when justified on the basis of the ship's characteristics and intended service. The calculations are to be submitted to the Society for approval.

4.1.3 Combined hull girder and local compression normal stresses

The combined compression normal stresses to be considered for the buckling check of ordinary stiffeners are to take into account the hull girder stresses and the local stresses resulting from the bending of the primary supporting members. These local stresses are to be obtained from a direct structural analysis using the design loads as given in Ch 1, Sec 4.

With respect to the reference co-ordinate system defined in Pt B, Ch 1, Sec 2, [4] of the Ship Rules, the combined stresses in x and y direction are obtained, in N/mm², from the following formulae:

$$\sigma_X = \sigma_{X1} + \gamma_{S2}\,\sigma_{X2,S} + \gamma_{W2}\,\sigma_{X2,W}$$

$$\sigma_Y = \gamma_{S2}\,\sigma_{Y2,S} + \gamma_{W2}\,\sigma_{Y2,W}$$

where:

σ_{X1} : Compression normal stress, in N/mm², induced by the hull girder still water and wave loads, defined in [3.4.2] and [4.1.2]

$\sigma_{X2,S}$, $\sigma_{Y2,S}$: Compression normal stress in x and y direction, respectively, in N/mm², induced by the local bending of the primary supporting members and obtained from a direct structural analysis using the still water design loads as given in Ch 1, Sec 4

$\sigma_{X2,W}$, $\sigma_{Y2,W}$: Compression normal stress in x and y direction, respectively, in N/mm², induced by the local bending of the primary supporting members and obtained from a direct structural analysis using the wave design loads as given in Ch 1, Sec 4.

4.2 Ultimate strength check

4.2.1 Application

The ultimate strength check of stiffeners subjected to lateral pressure and to hull girder normal stresses is to be checked according to Pt B, Ch 7, Sec 2, [5] of the Ship Rules.

4.2.2 Hull girder compression normal stresses

The hull girder compression normal stresses to be considered for the ultimate strength check of stiffeners contributing to the longitudinal strength are those given in [4.1]. The pressure to be considered is given in Ch 1, Sec 5.

5 Primary supporting members

5.1 General

5.1.1 Net thickness

The net thickness of plating which forms the webs of primary supporting members is to be in accordance with Part B, Chapter 7 and Pt D, Ch 7, Sec 3, [4.3] of the Ship Rules taking into account the requirements of the present Section.

Table 11 : Primary supporting members analysed through three dimensional models – Partial safety factors

Partial safety factors covering uncertainties regarding:	Symbol	Yielding check		Buckling check	
		General	Watertight bulkhead primary supporting members **(1)**	Plate panels	Pillars
Still water hull girder loads	γ_{S1}	1,00	1,00	1,00	1,00
Wave hull girder loads	γ_{W1}	1,02	1,02	1,02	1,02
Still water pressure	γ_{S2}	1,00	1,00	1,00	1,00
Wave pressure	γ_{W2}	1,07	1,07	1,07	1,07
Material	γ_m	1,02	1,02	1,02	1,02
Resistance	γ_R	defined in Tab 12	defined in Tab 12	1,02	see Pt B, Ch 7, Sec 3, Tab 3 of the Ship Rules

(1) Applies also to primary supporting members of bulkheads or inner side which constitute boundary of compartments not intended to carry liquids.

Note 1: For primary supporting members of the collision bulkhead, γ_R = 1,25.

Table 12 : Primary supporting members analysed through three dimensional or complete ship models Resistance partial safety factor

Type of three dimensional model	Resistance partial safety factor γ_R	
	General	Watertight bulkhead primary supporting members
Coarse mesh finite element model	1,15	1,02
Fine mesh finite element model	1,02	1,02

5.1.2 Finite element model

For the checking of the scantlings of the primary supporting members a three dimensional finite element model is required.

The check is to be made in accordance with Pt B, Ch 7, App 1 of the Ship Rules taking into account:

- the partial safety factors
- the wave loads
- the loading conditions
- the checking criteria,

given in the present document.

5.1.3 Number of models

Each typical cargo tank is to be subject of finite element calculation.

At least three cargo tanks are to be assessed:

- cargo oil tank at midship
- forward cargo tank
- afterward cargo tank.

5.1.4 Type of model

In case of an analysis based on coarse mesh model, the following fine mesh models are to be made:

- transverse rings
- primary supporting members supporting the transverse bulkheads
- bottom and deck girders.

5.2 Partial safety factors

5.2.1 The partial safety factors to be taken into account for the checking of the scantlings of the primary supporting members is given in Tab 11 and in Tab 12.

5.3 Structural modelling

5.3.1 The requirements given in Pt B, Ch 7, App 1, [3.1] (model construction), Pt B, Ch 7, App 1, [3.2] (model extension), Pt B, Ch 7, App 1, [3.3] (finite element modelling criteria), Pt B, Ch 7, App 1, [3.4] (finite element models) and Pt B, Ch 7, App 1, [3.6] (boundary conditions of the whole three dimensional model) of the Ship Rules remain applicable.

5.4 Load model

5.4.1 Loading conditions

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 and Fig 2.

When some of the load cases shown in Fig 1and Fig 2 are not included in the loading manual, and in particular, the alternate and the non symmetrical load cases, it must be indicated on the midship section drawing as well as in the loading manual, that these cases are not allowed. In addition, it should be demonstrated that these cases will never happen during the life of the unit, in particular in case of accidental conditions. In addition, conditions for inspection should be specified.

When the cases shown in Fig 1 and Fig 2 are foreseen in the loading manual, the analysis is to be carried out, taking into account the associated draughts as specified in the table, and not the draughts as given in the loading manual.

The filling of ballast tanks as indicated in Fig 1 and Fig 2 is given as default value and may be changed if available loading information indicates otherwise.

The loads of the topside facilities are to be added, in static conditions, to represent the light weight of the unit, as well as the weight of the external structures (riser supports, etc.).

5.4.2 Local loads

The profile pressures to be taken into account are those given in Ch 1, Sec 4.

The loads induced by the topside on deck are to be taken into account.

5.4.3 Hull girder loads

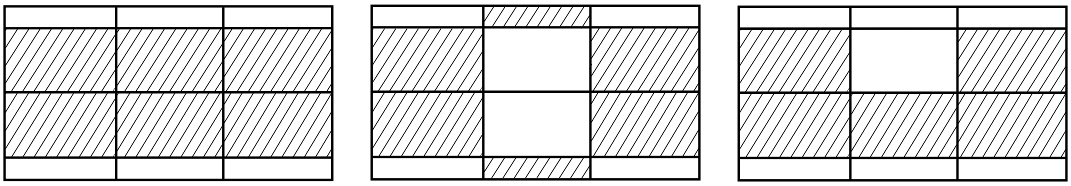
The hull girder loads to be taken into account are given in Tab 13 and Tab 14.

5.4.4 Load cases

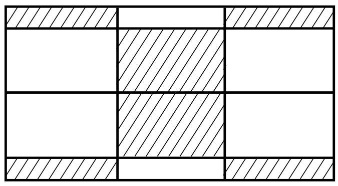
The loading conditions are to be combined with the load cases due to the sea at a probability level of $10^{-8,7}$. For the inspection cases the load cases may be taken into account at a reduced probability level if relevant.

Figure 1 : Loading conditions for units fitted with one central longitudinal bulkhead

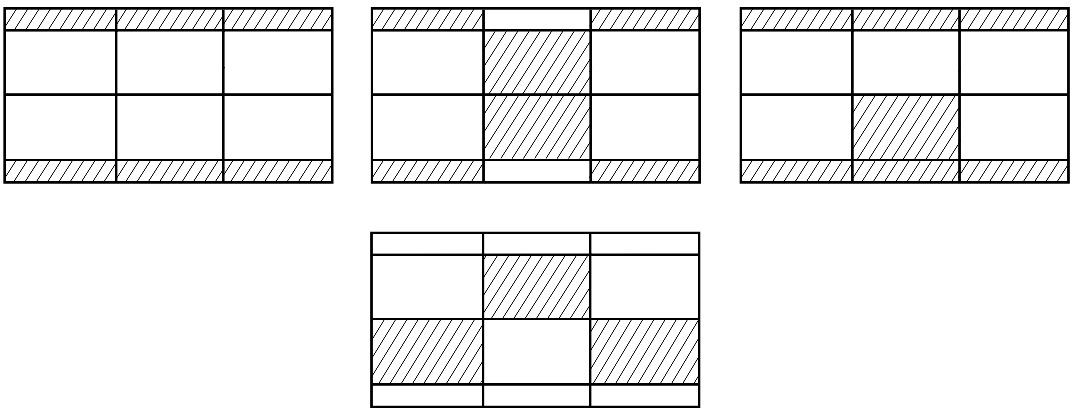
Loading conditions at maximum draught T



Loading condition at draught 0,9T



Loading conditions at minimum draught T_{mini}



Loading condition at draught 0,75T

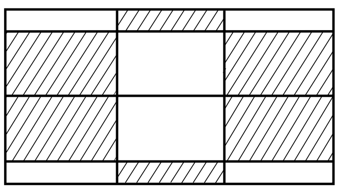
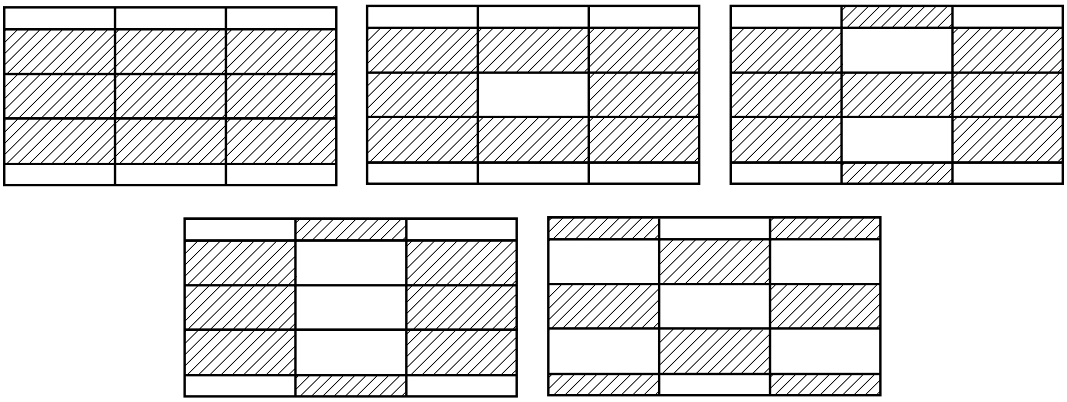
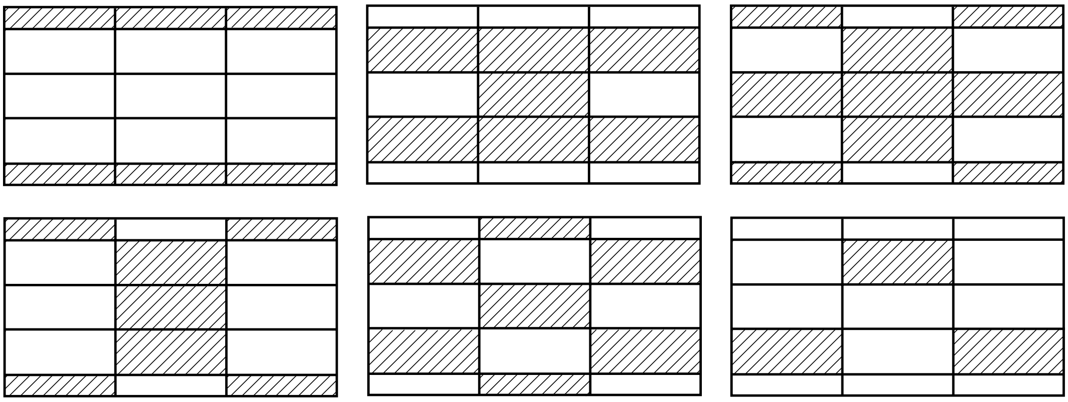


Figure 2 : Loading conditions for units fitted with two central longitudinal bulkhead

Loading conditions at maximum draught T



Loading conditions at minimum draught T_{mini}



Loading conditions at draught 0,75T

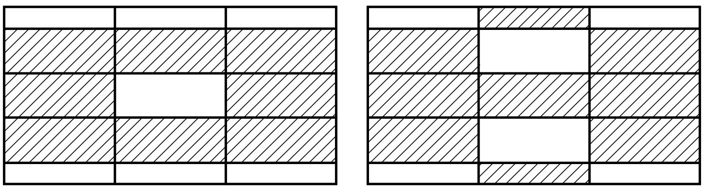


Table 13 : Hull girder loads - Maximal bending moments at the middle of the central tank/hold

Ship condition	Load case	Vertical bending moments at the middle of the central tank/hold		Horizontal wave bending moment at the middle of the central tank/hold	Vertical shear forces at the middle of the central tank/hold	
		Still water	Wave		Still water	Wave
Upright	“a” crest	γ_{S1} M_{SW}	γ_{W1} $M_{WV,H}$	0	0	0
	“a” trough	γ_{S1} M_{SW}	γ_{W1} $M_{WV,S}$	0	0	0
	“b”	γ_{S1} M_{SW}	γ_{W1} 0,7 $M_{WV,H}$	0	0	0
Inclined	“c”	γ_{S1} M_{SW}	γ_{W1} 0,4 M_{WV} **(1)**	γ_{W1} M_{WH}	0	0
	“d”	γ_{S1} M_{SW}	γ_{W1} 0,25 M_{WV} **(1)**	γ_{W1} M_{WH}	0	0

Note 1: Hull girder loads are to be calculated at the middle of the central tank/hold.
(1) M_{WV} is to be taken equal to $M_{WV,H}$ or to $M_{WV,S}$ depending on the case.

Table 14 : Hull girder loads - Maximal shear forces in way of the aft bulkhead of the central tank/hold

Ship condition	Load case	Vertical bending moments in way of the aft bulkhead of the central tank/hold		Vertical shear forces in way of the aft bulkhead of the central tank/hold	
		Still water	Wave	Still water	Wave
Upright	"a" crest	$\gamma_{S1}\, M_{SW}$	$\gamma_{W1}\, 0{,}4\, M_{WV,H}$	$\gamma_{S1}\, Q_{SW}$	$\gamma_{W1}\, Q_{WV}$
	"a" trough	$\gamma_{S1}\, M_{SW}$	$\gamma_{W1}\, 0{,}4\, M_{WV,S}$	$\gamma_{S1}\, Q_{SW}$	$\gamma_{W1}\, Q_{WV}$
	"b"	$\gamma_{S1}\, M_{SW}$	$\gamma_{W1}\, 0{,}4\, M_{WV,H}$	$\gamma_{S1}\, Q_{SW}$	$\gamma_{W1}\, 0{,}7\, Q_{WV}$
Note 1: Hull girder loads are to be calculated in way of the aft bulkhead of the central tank/hold.					

5.5 Yielding strength criteria for ship areas

5.5.1 General

For all types of analysis and for elements located in ship areas (as defined in Ch 1, Sec 3, [1]), it is to be checked that the equivalent stress σ_{VM} , calculated according to Pt B, Ch 7, App 1, [5] of the Ship Rules is in compliance with the following formula:

$$\frac{R_y}{\gamma_R \gamma_m} \geq \sigma_{VM}$$

5.5.2 Very fine mesh

In case of very fine mesh (typically 100mm x 100mm), the allowable equivalent stress is to be taken equal to 280/k. This stress is to be limited to one element. Adjacent elements have to satisfy the criteria in [5.5.1].

In case of finer mesh, average equivalent stress calculated over an area of 100mm x 100mm is to be less than 280/k.

5.6 Buckling check

5.6.1 A local buckling check is to be carried out, according to Article [2] for plate panels which constitute primary supporting members.

In carrying out this check, the stresses in the plate panels are to be calculated according to the present Article [5].

6 Offshore area

6.1 Strength criteria for offshore area

6.1.1 The allowable stresses for elements in offshore areas defined in Ch 1, Sec 3, [1.1] are given in Pt B, Ch 3, Sec 3.

7 Fatigue check of structural details

7.1 General

7.1.1 The structural details to be checked are those defined in [7.2].

The Society may require other details to be checked, when deemed necessary on the basis of the detail geometry and stress level.

7.1.2 The fatigue life and sea conditions of the unit, are to be specified by the owner, and to be indicated on the midship section drawing.

By default the fatigue life is 20 years, on site conditions.

7.1.3 Fatigue calculation is to be provided to the Society for design review. This calculation is generally to be a spectral fatigue analysis performed according to [7.3]. However a deterministic fatigue calculation may be carried out according to [7.4] at the pre-design stage. Deterministic fatigue calculation may be also carried out by the Society for verification of the spectral fatigue calculation.

The checking criteria are indicated in [5.5].

7.1.4 Corrosive environment is to be taken into account where there is no corrosion protection system. Information on the corrosion protection system, if any, is to be given by the Designer.

7.2 Structural details

7.2.1 The structural details to be checked are those defined in Pt B, Ch 12, App 2 of the Ship Rules for the service notation **oil tanker ESP**.

7.2.2 In addition, the following structural details are also to be checked:

a) In each typical cargo tank within the cargo tank area:
   - side shell, bottom and deck longitudinals with:
     - transverse oiltight & swash bulkheads
     - transverse web frame
   - ends or bracket ends of:
     - longitudinal girders
     - bottom transverse
     - horizontal stringers
     - vertical buttress supporting the horizontal stringer
   - flanges of transverse web frames in way of tripping brackets

b) Topside connection with the main deck

c) Crane pedestal

d) Mooring integration structure with hull (turret, buoy or spread mooring)

e) Flare tower connection with hull

f) Turret:

   The long term distribution of forces is to be submitted by the turret designer.

In addition to those details, the locations in which the calculated stress is higher than R_y, are to be assessed for fatigue.

Table 15 : Damage ratio

Consequence of failure	Degree of accessibility for inspection, maintenance and repair		
	Not accessible **(2)**	Underwater inspection **(3)**	Dry inspection
Critical **(1)**	0,1	0.25	0,5
Non-critical	0,2	0,5	1,0

(1) Critical damage as per risk analysis including loss of life, uncontrolled pollution, collision, sinking, other major damage to the installations and major production losses.
(2) Includes areas that can be inspected in dry or underwater conditions but require heavy works such as dry-docking for repair.
(3) Includes areas that can be inspected in dry conditions but with extensive preparation and heavy impact on operation.

7.3 Spectral fatigue analysis

7.3.1 The spectral fatigue analysis includes the following three steps:

- Hydrodynamic analysis:
  This analysis determines the external loads induced by the waves on the unit, and the resulting motions
- Structural analysis:
  Loads are applied on a structural model of the unit. The structural analysis provides the RAOs of stresses at location of interest, within the model
- Fatigue damage calculation based on statistics of stress ranges.

7.3.2 The spectral fatigue analysis is to take into account at least, except duly justified:

- 3 internal loading conditions, including minimum and maximum draughts
- 5 headings
- 25 frequencies.

7.3.3 Intermittent wetting effect, near free surface, is to be taken into account by means of an additional (differential) pressure loading on the side shell. Loading is defined for a representative finite wave height. The result is used to correct stiffener bending stress in intermittent wetting area, other contributions of this loading being negligible.

7.3.4 The overall (solid) mass is distributed on plate and beam elements by means of adjusted density. Weight of topsides modules are introduced according to the lightship weight distribution, by means of beam elements with no rigidity. The inertia loadings are generated from the above mass model and the accelerations of the vessel. Cargo and ballast tanks are loaded by internal fluid pressure calculated from acceleration at the centre of gravity of the tank (quasi-static approximation).

7.3.5 The short term distribution of hot spot stress ranges for a given sea-state is obtained by spectral analysis of the transfer function of hot spot stress ranges, and by Rayleigh statistics. The long term distribution, over a given period in time, is obtained by summation of the short term distributions, over the scatter diagram at site where the unit will operate.

7.3.6 The fatigue damage is evaluated from the distribution of stress ranges, by the Miner Sum.

7.3.7 Checking criteria

For the spectral analysis, the fatigue damage ratio is to be not greater than those given in Tab 15.

7.4 Deterministic fatigue analysis

7.4.1 General

The loads are to be determined according to [7.4.3]. The cumulative damage ratio is to be calculated according to the Ship Rules taking into account the requirements given in [7.4.6].

7.4.2 Partial safety factors

When the calculation is carried out using the loads derived from the hydrodynamic analysis, the partial safety factors to be taken into account are those given in Tab 16.

Where a navigation notation is granted to the unit, the partial safety factors to be taken into account are those given in Part B, Ch 7, Sec 4 of the Ship Rules.

Table 16 : Fatigue check – Partial safety factors

Partial safety factors covering uncertainties regarding:	Symbol	Value	
		General	Details at ends of ordinary stiffeners
Still water hull girder loads	γ_{S1}	1,00	1,00
Wave hull girder loads	γ_{W1}	1,03	1,11
Still water pressure	γ_{S2}	1,00	1,00
Wave pressure	γ_{W2}	1,07	1,15
Resistance	γ_R	1,02	1,02

7.4.3 Loads

The loads to be determined are the following ones:

- vertical wave bending moment
- accelerations
- relative wave elevation.

a) Where a navigation notation is granted to the unit, the loads to be taken into account in the deterministic fatigue analysis are those given in Pt B, Ch 7, Sec 4 of the Ship Rules.

b) Where no navigation notation is granted to the unit, the loads to be taken into account in the deterministic fatigue analysis are those given by the direct hydrodynamic calculations.

The loads may be taken at a probability level of 10^{-5}.

The pressures are calculated based on the above mentioned values, and the profile given in Ch 1, Sec 4.

Where the loads given by the direct hydrodynamic calculation are lower than those given by the navigation notation **sheltered waters**, these latter are to be taken into account.

7.4.4 Loading conditions

The calculations are generally to be carried out for 4 loading conditions with their associated draughts T_i, as defined in Tab 17, that are representative of the loading / unloading sequence of the unit.

However, more than 4 loading conditions can be considered on a case by case basis.

Table 17 : Loading conditions

Draught T_i	Loading condition "i"
Maximum T_{maxi}	Full load
Intermediate 1 By default: 2/3 T_{maxi} + 1/3 T_{mini}	Case by case By default: full load
Intermediate 2 By default: 1/3 T_{maxi} + 2/3 T_{mini}	Case by case By default: ballast
Minimum T_{mini}	Ballast

7.4.5 Elementary damage ratio

The elementary damage ratios are to be calculated according to Pt B, Ch 7, Sec 4 of the Ship Rules taking into account a sailing factor α_0 equal to 1.

The slope parameter ξ of the Weibull distribution of stress may be assessed on some structural details on a case by case basis, by calculation at different probability levels, generally 10^{-2}, 10^{-3}, 10^{-5}, 10^{-7}.

7.4.6 Cumulative damage ratio

The cumulative damage ratio is to be obtained from the following formula:

$$D = K_{cor}\sum_{i=1}^{4}\alpha_i D_i$$

where:

α_i : Part of the unit's life in loading condition "i" taken equal to 0,25 in case of 4 loading conditions.

The Society reserves its right to modify the values of the α_i coefficients

$$\sum_i \alpha_i = 1$$

D_i : Cumulative damage ratio for unit in loading condition "i"

$$D_i = \beta_{ab}\frac{D_{ai}+D_{bi}}{2} + \beta_c D_{ci} + \beta_d D_{di}$$

β_{ab}, β_c, β_d: Distribution coefficients for load cases "a", "b", "c", "d", as defined in Tab 18

Other values may be considered on a case by case basis

D_{ai}, D_{bi}, D_{ci}, D_{di} : Elementary damage ratios for load cases "a", "b", "c" and "d", respectively, in loading condition "i", as defined in [7.4.5]

K_{cor} : Corrosion factor, equal to:

- K_{cor} = 1,5 for cargo oil tanks
- K_{cor} = 1,1 for ballast tanks having an effective coating protection.

Table 18 : Distribution coefficients

	$T_i \geq \frac{T_{mini}+T_{maxi}}{2}$	$T_i < \frac{T_{mini}+T_{maxi}}{2}$
β_{ab}	1/3	2/3
β_c	1/3	1/3
β_d	1/3	0

7.4.7 Checking criteria

Where a navigation notation is granted to the unit, the criterion is the one given in Pt B, Ch 7, Sec 4 of the Ship Rules.

Where no navigation notation is granted to the unit, the damage ratio is to comply with the following formula:

$$D \leq \frac{0,5}{\gamma_R}$$

7.4.8 Loading / unloading

The fatigue due to loading/unloading may have to be assessed.

By default one loading/unloading per week is taken into account.

In this case the calculation should take into account the wave at a probability level not less than 10^{-4}.

SECTION 8 OTHER STRUCTURES

Symbols

c_a : Aspect ratio of the plate panel, equal to:

$$c_a = 1{,}21\sqrt{1 + 0{,}33\left(\frac{s}{\ell}\right)^2} - 0{,}69\frac{s}{\ell}$$

to be taken not greater than 1,0

c_r : Coefficient of curvature of the panel, equal to:

$c_r = 1 - 0{,}5\ s / r$

to be taken not less than 0,5

ℓ : Length, in m, of the longer side of the plate panel

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

1 Station keeping

1.1 General

1.1.1 Scope of Classification

The process of the Classification takes place in a procedure defining the interface between the work carried out by the mooring contractor and the one carried out by the shipyard.

The tasks to be carried out by the mooring contractor are detailed in the guidance note NI 493 "Classification of mooring systems for permanent offshore units".

The present [1] covers only the part concerning the hull.

1.1.2 Documents to be submitted

The following documents are to be submitted by the mooring designer:

a) specification of Design Limit Operational Conditions (DLOC) (for reference)
b) report of model test
c) mooring calculation
d) design load report (mooring loads)
e) design load report (loads on hull)
f) specification of explosion pressure
g) report of hydrodynamic analysis. This report includes loads induced by mooring, including dynamic effect on the buoy in the most severe conditions, and load distribution for fatigue assessment.

Note 1: For items b) to f), information is to be reviewed for the purpose of verification of the mooring interface load only.

1.2 Turret mooring system

1.2.1 General

The supporting structure of the turret is included in the scope of Classification and is part of the hull structure.

The structure supporting the turret mooring system is to be able to withstand the forces generated by the mooring.

1.2.2 Location of the turret mooring system

The turret mooring system may be:

- external:

  in this case, the turret may be located aft of the stern or forward the bow

- internal:

  in this case, the turret may be located all along the hull, inside the cargo tank area or not.

1.2.3 Longitudinal strength

The longitudinal strength of the hull girder at the location of the turret is to be checked according to Ch 1, Sec 6.

1.2.4 Calculation of the structure supporting the turret

A calculation using finite element method is to be carried out in order to verify the strength of the structure. If the turret is located:

- Forward the bow, externally of the structure:

  A local model is to be made.

- Within the forward structure, forward the cargo tank area:

  As a rule, the structure is to be modelled from the bow to the aft end of the cargo tank 1. The model may be clamped in way of the transverse bulkhead located at the aft end of the cargo tank n°1.

Note 1: For this calculation, there is no need of model balancing, but the mass are to be modelled as accurately as possible.

- Within the cargo tank area:

  As a rule, the model should include the adjacent cargo tanks, forward and aft the turret area. The model may be clamped at the end of one adjacent cargo tank. The model should be balanced by a adequate procedure (See Pt B, Ch 7, App 1 of the Ship Rules).

1.2.5 Mooring loads

The extreme loads on the structure are to be taken into account for different headings.

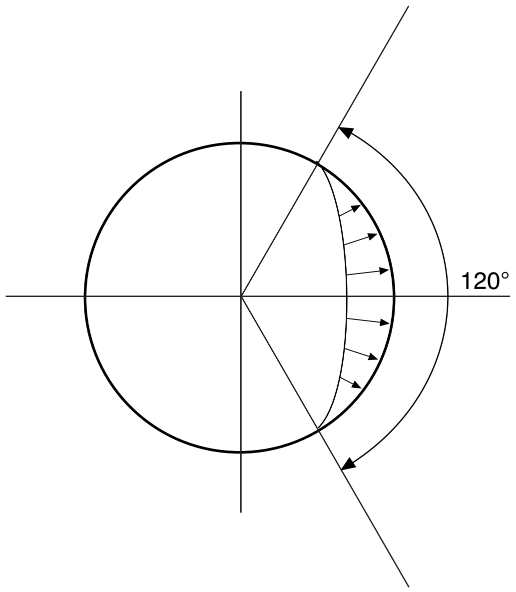
At least three headings are to be taken into account: 0°, 45°, 90° (or maximum heading from hydrodynamic analysis, not less than 60°, with associated mooring forces).

Other headings may be requested by the society, based on the design of the structure supporting the turret.

The turret is supported in the unit by a system of bearings.

The reaction forces in way of the bearings are to be distributed according to the design load report procedure. If this distribution is not specified, the reaction force is to be distributed according to Fig 1 i.e. over an 120° angle, with a cosine distribution.

Figure 1 : Heading for turret



1.3 Spread mooring system

1.3.1 General

The structure supporting the equipment of the mooring system (as defined in NI 493 "Classification of Mooring Systems for Permanent Offshore Units" are included in the scope of Classification and are considered as part of the hull structure.

The structure supporting the equipment of the mooring system is to be able to withstand the extreme mooring loads and fatigue forces.

1.3.2 Calculation of the supporting structure

A calculation using the finite element method is to be carried out in order to verify the strength of the structure for the forces submitted by the mooring designer. The extension and balancing of the model is to be agreed by the Society.

1.4 Calculations

1.4.1 Corrosion additions

The structure should be modelled in net scantlings.

The corrosion addition t_c, in mm, for each exposed side of plates is not to be less than 1 mm.

In case of disconnectable system, the corrosion addition in areas of friction, chocks, etc., may be increased at the Society satisfaction.

1.4.2 Load cases

The structural model is to take into account the following loads:

- Mooring loads:

  Mooring loads are to be determined in extreme conditions and are to be distributed according to the designer recommendation and to NI 493 Appendix 3 "Classification of Mooring Systems for Permanent Offshore Units"
- Hull girder loads:

  Hull girder loads to be taken into account are those with a probability level of $10^{-8,7}$, if relevant
- Local external loads, if relevant, i.e. sea pressures, liquid pressures (ballast and cargo) with accelerations given in Ch 1, Sec 4 including:
  - upright ship condition
  - inclined ship condition
- Internal loads:

  The calculation is to be carried out a least for two draughts:
  - minimum draught
  - maximum draught.

The partial safety factors are given in Ch 1, Sec 7.

1.4.3 Checking criteria

Allowable stresses are those given in Ch 1, Sec 7.

Buckling is to be checked according to Ch 1, Sec 7.

For fatigue analysis, the damage ratio is to be not greater than those given in Ch 1, Sec 7, Tab 15.

1.4.4 Materials and testing

For the steel grade selection, the structure supporting the equipments of the mooring system are considered as offshore unit specific area (see Ch 1, Sec 3).

2 Supports for hull attachments and appurtenances

2.1 General

2.1.1 The present article [2] is applicable to all major supports for hull attachments, such as:

- topsides
- risers and their protectors
- flare tower
- cranes
- offloading stations
- helideck
- boat landing platforms / stairtowers

2.1.2 The structure supporting the attachments is to be able to withstand the forces calculated for static, towing, operation and damage conditions. They are to be calculated by the constructing shipyard or attachment designer.

As a general rule, the affected supporting structure under the deck or inboard the side shell is to be considered as offshore area as defined in Ch 1, Sec 3, [1.1].

Cut outs in local structure in way of hull attachments are to be closed by full collar plates.

2.1.3 As a rule, the forces are to be calculated by the designer in four conditions as follows:

- static or operation conditions with $\alpha = 0,6$
- design conditions with $\alpha = 0,8$
- towing conditions with $\alpha = 0,8$
- accidental cases with $\alpha = 1,0$

where:

α : Basic allowable stress factor defined in Pt B, Ch 3, Sec 3, [5.4].

2.2 Calculations

2.2.1 Finite element calculation

A three dimensional finite element model of the support structure is to be submitted. A fine mesh of construction details is required.

The extension of the model is to be agreed by the Society.

2.2.2 Load cases

The model is to take into account:

- the design hull girder still water bending moment
- the wave induced bending moment at relevant probability level and, where relevant, the wave induced global hull shear stress, according to Ch 1, Sec 5, [3.2]
- the forces generated by the support structure on the hull.

2.2.3 Checking criteria

Allowable stress are those given in Pt B, Ch 3, Sec 3, [5].

Buckling is to be checked according to Ch 1, Sec 7.

For fatigue analysis, the damage ratio is to be not greater than those given in Ch 1, Sec 7, Tab 15.

2.2.4 Materials

For the steel grade selection, the top side support seat areas are considered as offshore unit specific area (see Ch 1, Sec 3).

3 Fore part

3.1 General

3.1.1 The scantlings and the arrangement of the fore part are to be in accordance with the requirements of Pt B, Ch 9, Sec 1 of the Ship Rules.

3.1.2 The flat bottom forward and the bow flare area are to be assessed according to the requirements given in [3.2] and [3.3].

Alternative method may be accepted on a case-by-case basis.

3.1.3 In case of turret mooring system, only the fore part is to be assessed according to [3.2] and [3.3].

In case of spread mooring, the Society may also request reinforcements according to [3.2] and [3.3] for the aft part.

3.2 Reinforcements of the flat bottom forward area

3.2.1 Area to be reinforced

In addition to the requirements in [3.1], the structures of the flat bottom forward area are to be able to sustain the dynamic pressures due to the bottom impact. The flat bottom forward area is:

- longitudinally, over the bottom located between ξ L and 0,05L aft of the fore end, where the coefficient ξ is obtained from the following formula:

  $\xi = 0,25\ (1,6 - C_B)$

  without being taken less than 0,2 or greater than 0,25
- transversely, over the whole flat bottom and the adjacent zones up to a height, from the base line, not less than 2L, in mm. In any case, it is not necessary that such height is greater than 300 mm.

3.2.2 Conditions of impact

The bottom dynamic impact pressure is to be considered if:

$T_F < \min\ (0,04L;\ 8,6\ \text{m})$

where T_F is the minimum forward draught, in m, among those foreseen in operation.

The value of the minimum forward draught T_F adopted for the calculations is to be specified in the loading manual.

An alternative arrangement and extension of strengthening with respect to the above may also be required where the minimum forward draught exceeds 0,04 L, depending on the shape of the forward hull body and the ship's length.

3.2.3 Bottom impact pressure

The bottom impact pressure p_{BI} is to be obtained, in kN/m², from the following formula:

$p_{BI} = 62\ C_1\ C_{SL}\ L^{0,6}$ if $L \le 135$

$p_{BI} = (1510 - 2,5\ L)\ C_1\ C_{SL}$ if $L > 135$

where:

$$C_1 = \frac{119 - 2300\dfrac{T_F}{L}}{78 + 1800\dfrac{T_F}{L}}$$ without being taken greater than 1,0

T_F : Draught defined in [3.2.2]

C_{SL} : Longitudinal distribution factor, taken equal to:

$C_{SL} = 0$ for $x \le x_1$

$C_{SL} = \dfrac{x - x_1}{x_2 - x_1}$ for $x_1 < x < x_2$

$C_{SL} = 1$ for $x \ge x_2$

$$x_1 = \left(0,55 + \frac{L}{2000}\right)L$$

$$x_2 = \left(0,35 + 0,5C_B + \frac{L}{3000}\right)L \text{ with } 0,6 \le C_B \le 0,85$$

Note 1: When f_{RWE} is greater than 1, bow impact pressure should be considered on a case by case basis.

3.2.4 Partial safety factors

The partial safety factors to be considered for checking the reinforcements of the flat bottom forward area are specified in Tab 1.

Table 1 : Reinforcements of the flat bottom forward area - Partial safety factors

Partial safety factors covering uncertainties regarding:	Partial safety factors		
	Symbol	Plating	Ordinary stiffeners
Still water pressure	γ_{S2}	1,00	1,00
Wave pressure	γ_{W2}	1,10	1,10
Material	γ_m	1,02	1,02
Resistance	γ_R	1,30	1,05

3.2.5 Scantlings

In addition to the requirements in Pt B, Ch 9, Sec 1, [2.4.1] and Pt B, Ch 9, Sec 1, [2.5.1] of the Ship Rules, the net scantlings of plating and ordinary stiffeners of the flat bottom forward area, defined in [3.2.1] and [3.2.2], are to be not less than the values obtained from the formulae in Tab 2 and the minimum values in the same Table.

Outside the flat bottom forward area, scantlings are to be gradually tapered so as to reach the values required for the areas considered.

The scantlings of the primary supporting members are to be checked according to Pt B, Ch 9, Sec 1, [3.4.3] of the Ship Rules taking into account a pressure of 0,3 p_{BI} over the ship breadth and over one floor spacing in the longitudinal direction.

3.2.6 Arrangement of primary supporting members and ordinary stiffeners

Arrangement of primary supporting members and ordinary stiffeners are to be in accordance with the requirements of Pt B, Ch 9, Sec 1, [3.5] of the Ship Rules for longitudinally framed bottom and Pt B, Ch 9, Sec 1, [3.6] of the Ship Rules for transversely framed double bottom.

3.3 Reinforcements of the bow flare area

3.3.1 Area to be reinforced

In addition to the requirements in [3.1], the structures of the bow flare area are to be able to sustain the dynamic pressures due to the bow impact pressure.

The bow area to be reinforced is that extending forward of 0,9 L from the aft end and above the summer load waterline up to the level at which a knuckle with an angle greater than 15° is located on the side shell.

3.3.2 Bow impact pressure

The bow impact pressure p_{FI} is to be obtained, in kN/m², from the following formula:

$$p_{FI} = C_S C_L C_Z (0{,}22 + 0{,}15 \tan\alpha)(k \sin\beta + 0{,}6\sqrt{L})^2$$

where:

C_S : Coefficient depending on the type of structures on which the bow impact pressure is considered to be acting:

- C_S = 1,8 for plating and ordinary stiffeners
- C_S = 0,5 for primary supporting members

C_L : Coefficient depending on the ship's length:

- C_L = 0,0125 L for L < 80 m
- C_L = 1,0 for L ≥ 80 m

C_Z : Coefficient depending on the distance between the summer load waterline and the calculation point:

- $C_Z = C - 0{,}5\,(z - T)$ for $z \geq 2\,C + T - 11$
- $C_Z = 5{,}5$ for $z < 2\,C + T - 11$

C : Wave parameter, defined in Ch 1, Sec 5

α : Flare angle at the calculation point, defined as the angle between a vertical line and the tangent to the side plating, measured in a vertical plane normal to the horizontal tangent to the shell plating (see Fig 2)

Figure 2 : Definition of angles α and β

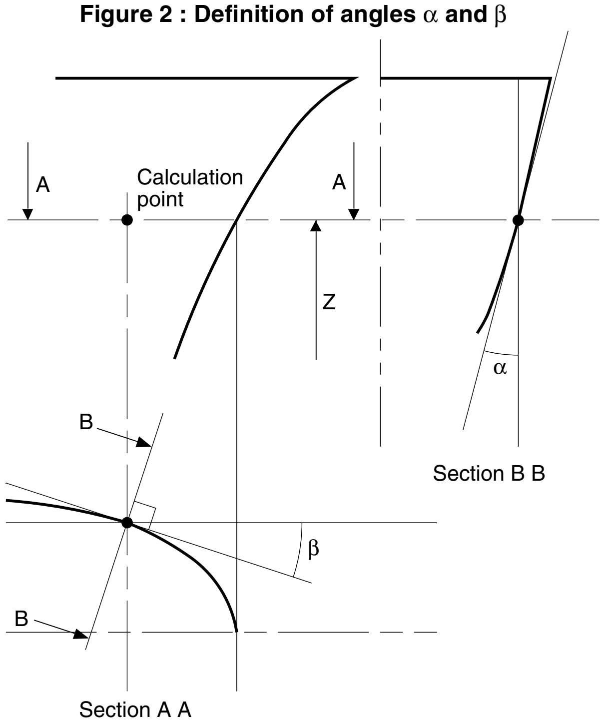


Table 2 : Reinforcements of plating and ordinary stiffeners of the flat bottom forward area

Element	Formula	Minimum value
Plating	Net thickness, in mm: $t = 14{,}9 c_a c_r s \sqrt{\gamma_R \gamma_m \frac{\gamma_{W2} p_{BI}}{R_y}}$	Net minimum thickness, in mm: $t = (0{,}03\,L + 5{,}5)\,k^{1/2}$
Ordinary stiffeners	Net section modulus, in cm³: $w = \gamma_R \gamma_m \beta_b \frac{\gamma_{W2} p_{BI}}{12 R_y}\left(1 - \frac{s}{2\ell}\right) s \ell^2 10^3$	Web net minimum thickness, in mm, to be not less than the lesser of: • $t = 1{,}5\,L_2^{1/3}\,k^{1/6}$ • the net thickness of the attached plating
	Net shear sectional area, in cm²: $A_{Sh} = 10 \gamma_R \gamma_m \beta_s \frac{\gamma_{W2} p_{BI}}{R_y}\left(1 - \frac{s}{2\ell}\right) s \ell$	

β : Entry angle at the calculation point, defined as the angle between a longitudinal line parallel to the centreline and the tangent to the shell plating in a horizontal plane (see Fig 2).

k : Parameter to be taken equal to 4,8

The Society may accept a reduction of this parameter on a case by case basis.

Note 1: When f_{RWE} is greater than 1, bow impact pressure should be considered on a case by case basis.

3.3.3 Partial safety factors

The partial safety factors to be considered for checking the reinforcements of the bow flare area are specified in Tab 3.

3.3.4 Scantlings

In addition to the requirements in Pt B, Ch 9, Sec 1, [2.6.1] and Pt B, Ch 9, Sec 1, [2.7.1] of the Ship Rules, the net scantlings of plating and ordinary stiffeners of the bow flare area, defined in [3.3.1], are to be not less than the values obtained from the formulae in Tab 4 and the minimum values in the same table.

Outside the bow flare area, scantlings are to be gradually tapered so as to reach the values required for the areas considered.

Intercostal stiffeners are to be fitted at mid-span where the angle between the stiffener web and the attached plating is less than 70°.

Primary supporting members are generally to be verified through direct calculations carried out according to Pt B, Ch 7, Sec 3 of the Ship Rules considering the bow impact pressures defined in [3.3.2].

4 Aft part

4.1 General

4.1.1 The aft part arrangement is to be in accordance with Pt B, Ch 9, Sec 2 of the Ship Rules.

Table 3 : Reinforcements of the bow flare area Partial safety factors

Partial safety factors covering uncertainties regarding:	Partial safety factors		
	Symbol	Plating	Ordinary stiffeners
Still water pressure	γ_{S2}	1,00	1,00
Wave pressure	γ_{W2}	1,10	1,10
Material	γ_m	1,02	1,02
Resistance	γ_R	1,30	1,02

4.2 Spread mooring

4.2.1 In case of spread mooring, the Society may also request reinforcements according to [3.2] and [3.3] for the aft part.

5 Superstructures and deckhouses

5.1 General

5.1.1 The superstructures and deckhouses are to be in accordance with the requirements of Pt B, Ch 9, Sec 4 of the Ship Rules.

5.1.2 When the superstructures are not directly located on the free-board deck but supported by pillars, a global strength calculation of the structure supporting the superstructures is to be submitted according to methods, standards or codes recognised by the Society.

The lateral pressures on the superstructures are to be calculated as defined in Pt B, Ch 9, Sec 4, [2] of the Ship Rules. When the height of the supporting pillars is equivalent to a standard superstructure height, the lowest tier of the superstructure is to be considered as the second tier of the superstructure; when the height of the supporting pillars is equivalent to two standard superstructure heights, the lowest tier of the superstructure is to be considered as the third tier of the superstructure, and so on.

Table 4 : Reinforcements of plating and ordinary stiffeners of the bow flare area

Element	Formula	Minimum value
Plating	Net thickness, in mm: $t = 11 c_a c_r s \sqrt{\gamma_R \gamma_m \frac{\gamma_{W2} p_{FI}}{R_y}}$	Net minimum thickness, in mm: $t = (0{,}03\ L + 5{,}5)\ k^{1/2}$
Ordinary stiffeners	Net section modulus, in cm^3: $w = \gamma_R \gamma_m \beta_b \frac{\gamma_{W2} p_{FI}}{20 R_y}\left(1 - \frac{s}{2\ell}\right) s \ell^2 10^3$	Web net minimum thickness, in mm, to be not less than the lesser of: • $t = 1{,}5\ L_2^{1/3}\ k^{1/6}$ • the net thickness of the attached plating.
	Net shear sectional area, in cm^2: $A_{Sh} = 8 \gamma_R \gamma_m \beta_s \frac{\gamma_{W2} p_{FI}}{R_y}\left(1 - \frac{s}{2\ell}\right) s \ell$	

6 Helicopter deck

6.1 Reference standards

6.1.1 The arrangement, maintenance are to be in accordance with the Civil Aviation Publication 437 "Offshore Helicopter Landing Areas – Guidance on Standards" (CAP 437).

6.2 Structure

6.2.1 The scantlings of the structure are to be in accordance with the requirements of Pt B, Ch 9, Sec 10 of the Ship Rules.

7 Hull outfitting

7.1 Bulwarks and guard rails

7.1.1 Bulwarks and guard rails are to comply with the requirements of Pt B, Ch 10, Sec 2 of the Ship Rules.

In topsides, the perimeter of all open deck areas, walkways around accommodation spaces, catwalks and openings are also to be protected with similar guard rails.

7.1.2 In case of large bulwarks a direct calculation (including fatigue calculations) may be requested by the Society.

7.2 Towing arrangement

7.2.1 The towing arrangement is to be in accordance with Pt B, Ch 10, Sec 4, [4] of the Ship Rules.

8 Launching appliances

8.1 Launching appliances used for survival craft or rescue boat

8.1.1 Appliances are in ship area and are to follow the requirement of Part B, Ch 8, Sec 4 [2.6] of the Ship Rules.

SECTION 9 LOCAL STRUCTURAL IMPROVEMENTS

1 Protection of hull metallic structures

1.1 General

1.1.1 Protection system

It is the responsibility of the party applying for classification to choose the system that will perform the protection of the structure against corrosion.

A protection system is composed of using one or a combination of the following methods:

- application of protective coatings
- cathodic protection
- selection of material.

It is also the responsibility of the party applying for classification to have the system applied in accordance with the manufacturer's requirements.

1.1.2 Protection methods

The protection methods, the design of corrosion protection systems is to be in accordance with the requirements of Part B, Chapter 3.

1.2 Plan for the corrosion

1.2.1 An overall plan for the corrosion protection of the structure is to be prepared and submitted to the Society, in accordance with the provisions of Part B, Chapter 3.

The plan for the corrosion is to cover the following areas of the structure:

- all external areas (submerged, splash zone,...)
- internal areas (ballast, storage tanks,...).

The plan for the corrosion is to take into account:

- the intended duration of operations and conditions of maintenance
- the particular conditions in each area.

In case of a converted unit the plan for the corrosion is also to take into account the initial conditions of structure (unless renewed during conversion work).

1.3 Thickness increments

1.3.1 Thickness increments are to be in accordance with the requirements of Ch 1, Sec 3, [4.2].

2 Post welding treatment

2.1 Scope

2.1.1 General

In normal design and building conditions, post welding treatments are not applied.

The decisions to apply a post welding treatment may be required for specific hot spots, on a case-by-case basis, where the damage ratio is closed to the limit and in case of repair.

2.1.2 Conditions of application

Full penetration welding is to be adopted. Post welding treatment of partial penetrations is not accepted.

The post welding treatment procedure is to be performed according to a recognized standard and approved by the Society.

2.1.3 Mechanical post welding treatment

The following mechanical post welding treatments are accepted:

- grinding
- shot peening
- needle peening
- ultrasonic peening.

In principle, hammer peening is not accepted.

2.1.4 Thermal post welding treatment

The following thermal post welding treatments are accepted:

- TIG refusion
- plasma refusion.

2.2 Fatigue resistance assessment

2.2.1 General

These treatments improve the weld toe and the residual stresses leading to an increase of the S-N curve class.

The post weld S-N curve may have a different slope than the as welded S-N curve.

2.2.2 Assessment

The fatigue lifetime of the treated details is to be assessed taking into account the modified S-N curves. The used S-N curves are to be duly justified, by fatigue tests or by a recognized standard.

2.2.3 Experimental S-N curves

When tests are considered to determine the S-N curve, the test program has to be approved by the Society.

Attention is to be paid to the necessary number of samples, and the distribution of the results along the stress range axis to allow a correct determination of the S-N curve slope and standard deviation.

To be homogeneous with the Rules for as welded joints, the design curve will correspond to a curve, at minus 2 standard deviations, and taking into account confidence intervals of the calculated mean and standard deviation.

3 Protection to explosions

3.1 General

3.1.1 Scope

Due to leakages explosive gas clouds can happen. The scope of the following requirements is to provide rules for the verification of the structure safety with respect to explosion of such clouds.

The requirements are eligible for the verification of the resistance of hull structure components submitted to a shock pressure wave.

The types of explosions to be assessed are:

- from an open air cloud (external explosion)
- between main deck and process deck (tunnel explosion)
- inside closed capacities (internal explosion).

3.1.2 Safety criteria

The safety principle is that the structural elements may suffer permanent deformations without any rupture allowing the transmission of the pressure waves and hot gases or liquids through the steel panels.

For internal explosions the above principle can be fulfilled in two ways:

- the boundary structure of the capacity resists to the extreme possible pressure wave
- the capacity is equipped by a system allowing a limitation of the maximum pressure such as relief valves or sacrificial panels.

3.1.3 Explosion characteristics

The explosion is characterized by 2 parameters:

- the equivalent exploded TNT mass
- the distance from the explosion location to the verified ship structural component.

The explosion is considered occurring with stoechiometric conditions.

Note 1: 1 kg hydrocarbon (gas or liquid) is equivalent to 1 kg of TNT.

3.1.4 Structural detail design

To improve the resistance to explosion loads, structural details have to be designed to allow a good transmission of the in-plane forces.

Details have to be designed to allow in plane deformation with as low as possible punching effect and shear failure of welds.

3.1.5 Calculation to be submitted

The following documents are to be submitted to the Society for information:

- equivalent exploded TNT mass calculation
- pressure profile and maximum pressure of the shock wave justifications. The pressure wave can be determined either by test results or either a recognized computation fluid dynamic tool
- the finite element model with the modelling hypothesis (element types, boundary conditions, damping, loading cases, load phases, etc.)
- response and resistance of the structural elements calculation
- arrangement of the maximum pressure limitation system and operating assessment.

3.2 Areas to be considered

3.2.1 Turret and turret moonpool

Leakage can occur inside such spaces with generation of an explosive atmosphere.

In case of explosion, the spaces boundaries with the surrounding hull structure should have to resist to the internal explosions. For the protection principles see [3.1.2].

3.2.2 Main deck

The main deck may have parts below the process deck or in open air.

For the parts below the process deck, due to possible leakage, it can be exposed to explosions of type tunnel explosion.

For the parts in open air, they can be exposed to explosions occurring outside the topside equipment. The type of explosion to be considered is aerial explosions.

3.2.3 Superstructure front

The superstructure front can be exposed to explosions occurring outside the topside equipment.

When specified superstructure front resistance has to be assessed. The type of explosion to be considered is aerial explosions.

3.2.4 Tanks

Except otherwise specified no assessment is required for tank boundary resistance to internal explosions.

3.3 Criteria

3.3.1 Criteria for the shell and bulkheads

The ultimate strength of structural components is defined in terms of non rupture of the component after the shock load action.

For shell and bulkhead panels the maximum strains in model elements have to be determined.

The following criteria are to be fulfilled, versus the modelling (see [3.4.1]):

- the maximum element deformation $\in_M$ for elasto-plastic calculations:

  $\in_M \leq 0,8 \in_{Ult}$

  where $\in_{Ult}$ is the material ultimate strength elongation
- the maximum stress σ_M for elastic calculations

  $\sigma_M \leq 0,8\ E \in_{Ult}$

  where E is the material Young modulus.

3.3.2 Sacrificial panel

Under the maximum specified pressure, the opening of the area covered by the sacrificial panel is to be sufficient to allow a gas flow stopping the shock wave pressure increase.

When structural elements exist in the gas flow their resistance to the drag forces has to be assessed.

3.3.3 Relief valves

Under the maximum specified pressure, the relief valve openings are to be sufficient to allow a gas flow stopping the shock wave pressure increase.

3.4 Methodology

3.4.1 General

Explosion is a transient dynamic phenomenon. The response can be assessed by an adequate finite element software.

At a pre-design stage, 1 Degree Of Freedom (DOF) mass-spring modelling can be used to assess the elastic response of the structural components. A finite element model is to be done to determine the free modes from which the 1DOF models will be selected.

At design stage, the assessment is to be done using a finite element model either elastic or elastoplastic.

3.4.2 Free mode determination

The boundary conditions are to be carefully determined.

In particular the boundaries are to be located in way of continuous bulkheads or floors.

3.4.3 Modelling

a) 1 DOF mass-spring model

The free modes, which half periods are in the vicinity of the pressure shock wave durations, can be represented by a 1 DOF system.

The 1 DOF system is characterised by:

- free frequency equal to the represented component free mode period
- spring stiffness so that the displacement of the 1 DOF system under a static unit force is equal to the maximum deflection of the structural component under a uniform static pressure corresponding to the unit force
- for the transient response calculation, the damping can be neglected.

b) Finite element model

The finite element model is to take into account:

- the dynamic response of the panel under impulsive loads
- the liquid added mass effects for wet components
- the structural damping and, when relevant, the hydrodynamic damping (see [3.4.4])
- the large deformation effects
- the material plastification effects, when elasto-plastic calculations are carried out.

The model size and finite element types have to be able to determine accurately:

- the correct component deformation under static and impulsive transient pressure
- the correct stress fields, in particular in way of areas with stress concentration
- at least the 2 first free vibration modes of the components of highest free frequencies
- the plastification characteristics of the elements, when elasto-plastic calculations are carried out.

3.4.4 Damping

The structural damping ratio (in percent of critical damping) can be taken equal to 10%.

The hydrodynamic damping ratio is to be determined by a recognized method.

3.4.5 Model response calculation

The response has to be computed during the explosion wave pressure duration and after on a time length corresponding, at least, to 2 times the largest period of the structural component first mode.

For panels and structural components response, the response has to be computed taking into account the shock wave pressure (see [3.5]).

a) 1 DOF mass-spring model

The equivalent static pressure is determined taking into account the maximum displacement of the 1 DOF model.

Elastic calculation under static loads allows to assess the stresses and strains of the model.

b) Finite element model

The stresses and strains calculated through a finite element model are to comply with the criteria given in [3.3].

3.5 Explosion pressure wave loads

3.5.1 Definitions

W : Equivalent exploded TNT mass, in kg

D : Minimum distance from the plating component to the explosion location, in m.

3.5.2 External explosion

The shock wave pressure, at a given location versus time is given by the following equation:

$P = P_M \exp(- n\, t)$

where:

P_M : Maximum shock wave pressure, in kN/m², given by:

$$P_M = 730\frac{W^{0,527}}{D^{1,58}}$$

n : Decay shock wave pressure parameter, in sec, given by:

$$\frac{1}{n} = 0,48W^{0,196}D^{0,38}10^{-3}$$

3.5.3 Internal explosion

For internal explosion, the pressure profile is to be a triangle, which characteristics: maximum pressure, rise time, decay time to 0, are functions of the dynamic boundary characteristics and are to be duly justified.

The pressure profile characteristics can be determined from results of tests or a computational fluid dynamic tool.

3.5.4 Tunnel explosion

For tunnel explosion, the pressure profile is to be a triangle, which characteristics: maximum pressure, rise time, decay time to 0, are to be duly justified.

The pressure profile characteristics can be determined from results of tests or a computational fluid dynamic tool.

4 Minor collision

4.1 General

4.1.1 Scope

Due to operations around the unit collisions can happen. The scope of the following requirements is to provide rules for the verification of the structure safety with respect to such events.

The requirements are eligible for the verification of the resistance of side shell structure submitted to a collision from a vessel which dimensions are small compared to the dimensions of the unit.

4.1.2 Safety principle

The energy of the colliding vessel is to be absorbed by the deformed side shell of the unit without risk of flooding.

Therefore the safety criterion is that the structural elements may suffer permanent deformations without any rupture.

4.1.3 Calculations to be submitted

The following documents are to be submitted to the Society for information:

- list of shuttle tankers and supply vessels intended to be operated during the unit life and selected vessels
- colliding speeds and justification
- colliding energy calculation of the selected colliding vessels
- side shell energy deformations versus bow indentations until first shell plate rupture.

4.2 Risk analysis

4.2.1 A risk analysis is to be performed taking into account the boats operating around the unit, such as supply boats, shuttle tanker, etc.

The risk analysis is to determine, for each vessel operating around the unit, the speed, the mass and the associated probability of collision.

4.3 Assessment conditions

4.3.1 Areas to be considered

The following areas of the unit are to be considered:

- bow
- free side shell between two transverse bulkheads
- free side shell at the level of the first transverse ring from a transverse bulkhead.

In addition, the following areas are to be considered, when relevant:

- side shell at spread mooring zones
- side shell at the offloading line protection zones
- side shell at the riser zones
- side shell at the turret.

4.3.2 Collision characteristics

The colliding vessel is considered hitting the side shell by the bow at 90°.

The colliding vessel sizes and bow shapes (with or without bulb) to be considered are selected from the list of shuttle tankers and supply vessels intended to be operated during the unit life.

The colliding vessel speed is to be fixed considering the operation instructions. Without any informations, the speed is to be taken equal to 10 knots.

4.3.3 Colliding energy

The colliding vessel energy E_c, in kJ, is to be taken equal to:

$$E_C = \frac{1}{2}\frac{M_a M_b}{M_a + M_b}V^2$$

where:

M_a, M_b : Unit and colliding vessel mass, in tons, including the added water mass

V : Speed of the colliding ship, in m/s.

4.3.4 Criteria

The considered limit state is the first rupture of a plate in the indented (crushed) area of the unit.

4.4 Methodology

4.4.1 Bow behaviour

The bow of the colliding ship is considered non deformable. Therefore the geometrical contour of the bow defines the indented area of the unit.

4.4.2 Finite element calculation

Finite element calculations are to be performed step by step of indentation until the limit state is reached, using a non linear elastoplastic recognized software.

4.4.3 Analytical methods

As an alternative, analytical methods, such as Mc Dermott and Rosenblatt methods can be applied.

4.4.4 Results

The results to be provided are:

- the absorbed deformation energy versus indentation steps, until the limit state is reached
- the deformed structure at the limit state
- the list of the cracked plates.

5 Dropped objects

5.1 General

5.1.1 Scope

When specified, deck plate resistance to drops of equipments may be checked.

The requirements are eligible for the verification of the resistance of deck structure components submitted to the impact of a solid body.

5.1.2 Safety principle

Therefore the safety criteria is that the structural elements may suffer permanent deformations without any rupture.

5.1.3 Calculations to be submitted

The following documents are to be submitted to the Society for information:

- equipment considered that may fall on the deck with mass
- maximum dropped height and justification
- deck areas to be assessed
- deck modelling
- dropping object modelling
- deck response and extreme deformations.

5.2 Methodology

5.2.1 Dropping object

The dropping object is modelled in such a way that its contact area and stiffness behaviour are respected.

5.2.2 Deck structure

Depending on the size of the dropping object, the deck structure to be modelled is a panel between primary supporting members, or bulkheads / side shell.

5.2.3 Procedure

The dropping object is considered as deforming the deck structure by step by step static indentation, both being deformable, taking into account the relative stiffness.

The indentation is performed until the limit state is reached, as defined in [5.2.4].

5.2.4 Criteria

The energy of the dropping object at the moment of the contact with the deck is to be lower than the absorbed energy by the deck deformation at the limit state.

The limit state corresponds to the first rupture of a plate in the deformed deck area.

5.2.5 Finite element calculation

Finite element calculations are to be performed until the limit state is reached, using a non linear elastoplastic recognized software.

5.2.6 Results

The results to be provided are:

- the absorbed deformation energy versus indentation steps, until the limit state is reached
- the deformed structure at the limit state
- the list of the cracked deck plates.

SECTION 10 ACCESS, OPENINGS, VENTILATION AND VENTING OF SPACES IN THE STORAGE AREA

1 Access, openings and ventilation

1.1 General

1.1.1 Unless otherwise specified in the present Chapter, access to cofferdams, ballast tanks, cargo tanks, and other compartments in the storage area is to be direct from the open deck and such as to ensure their complete inspection. Openings for cargo tank sounding, washing, ventilation, etc., are to be located above the open deck.

1.1.2 Provisions are to be made to ensure efficient ventilation of each of these spaces. Unless otherwise specified in the present Chapter, portable means are permitted for that purpose. Ventilation fans are to be fitted according to [1.3.7].

1.1.3 The requirement of SOLAS Regulation II-1/3-6 is not necessary to be complied with except if the unit is subject to Enhanced Survey Program as specified in IMO Resolution A.744(18) as amended.

1.2 Arrangement of cargo pump rooms

1.2.1 Cargo pump rooms are to be so arranged as to permit free access to all cargo handling valves and facilitate the hoisting of an injured person from the bottom of the space.

1.2.2 Main ladders are not to be fitted vertically, unless justified otherwise by the size of the cargo pump room.

Rest platforms are to be provided at suitable intervals not more than 10 m in height apart. Ladders are to be fitted with handrails and are to be securely attached to the unit's structure.

1.2.3 Where cargo pumps, ballast pumps and stripping pumps are driven by a machinery which is located outside the cargo pump room, the following arrangement are to be provided:

- drive shafts are to be fitted with flexible couplings or other means suitable to compensate for any misalignment
- 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 sufficiently 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
- temperature devices are to be fitted for bulkhead shaft glands, bearings and pump casings.

1.2.4 To discourage personnel from entering the cargo pump room when the ventilation is not in operation, the lightening in the cargo pump room is to be interlocked with ventilation such that ventilation is to be in operation to energize the lightening.

Failure of the ventilation system is not to cause the lightening to go out; emergency lightening, if fitted, is not to be interlocked.

1.2.5 A system for continuous monitoring the concentration of hydrocarbon gases shall be fitted. Sampling points or detector heads shall be located in suitable positions in order that potentially dangerous leakages are readily detected. When the hydrocarbon concentration reaches a pre-set level, which shall not be higher than 10% of the lower flammable limit, a continuous audible and visual alarm signal shall be automatically effected in the cargo pump room, engine room, cargo control room and in the central control room to alert personnel to the potential hazard.

1.2.6 All cargo pump rooms shall be provided with bilge level monitoring devices with appropriately located alarms.

High liquid level in the bilges is to activate an audible and visual alarm in the cargo control room and in the central control station.

1.3 Ventilation of cargo pump room

1.3.1 Cargo pump rooms are to be provided with a suction type mechanical ventilation system. The ventilation of these rooms is to have sufficient capacity to avoid the accumulation of flammable vapours. The number of changes of air is to be at least 20 per hour, based upon the gross volume of the space. The air ducts are to be arranged so that all of the space is effectively ventilated.

1.3.2 Ventilation ducts are to be so arranged as to avoid air pockets. In particular:

a) The ventilation ducts are to be so arranged that their suction is just above the transverse floor plates or bottom longitudinal in the vicinity of bilges.

b) An emergency intake located about 2,20 m above the pump room lower grating is to be provided. It is to be fitted with a damper capable of being opened or closed from the exposed main deck and lower grating level.

   Ventilation through the emergency intake is to be effective when the lower intakes are sealed off due to flooding in the bilges.

c) The foregoing exhaust system is in association with open grating floor plates to allow the free flow of air.

d) Arrangements involving a specific ratio of areas of upper emergency and lower main ventilator openings, which can be shown to result in at least the required 20 air changes per hour through the lower inlets, can be adopted without the use of dampers. When the lower access inlets are closed then at least 15 air changes per hour should be obtained through the upper inlets.

1.3.3 The ventilation ducts are to be led direct to atmosphere at a safe place on open deck, and are not to pass through gas safe spaces, cargo tanks or slop tanks.

1.3.4 Ventilation exhaust ducts are to discharge upwards in locations at least 8 m from any ventilation intake and opening to gas safe spaces.

Ventilation intakes are to be so arranged as to minimise the possibility of recycling hazardous vapours from ventilation discharge openings.

1.3.5 Protection screens of not more than 13 mm square mesh and fire dampers are to be fitted on ventilation duct intakes and outlets.

1.3.6 Ventilation fans are to be capable of being controlled from outside of cargo pump rooms.

1.3.7 Electric motors driving fans are to be placed outside the ventilation ducts. Ventilation fans are to be of non-sparking type (see Pt C, Ch 4, Sec 1, [3.6.10]).

1.4 Ventilation of pump rooms

1.4.1 Pump rooms other than those considered as equivalent to cargo pump rooms in application of Ch 1, Sec 2, [3.4.3] are to be provided with means of access and ventilation systems at the satisfaction of the Society.

1.4.2 Ventilation of pump rooms containing:

- ballast pumps serving spaces adjacent to cargo or slop tanks, and
- oil fuel pumps,

is to comply with [1.3.1], [1.3.3], [1.3.4], and [1.3.7].

1.5 Cargo compartments

1.5.1 Each cargo tank is to be provided with an access hatch with a clear opening at least equivalent to a circle of 600 mm in diameter.

1.5.2 Covers fitted on all cargo tank openings are to be of sturdy construction, and to ensure tightness for liquid hydrocarbon and water.

1.5.3 Access ladders of cargo tanks are not to be fitted vertically, unless justified otherwise by the size of the tanks.

Rest platforms are to be provided at suitable intervals not more than 10 m in height apart. Ladders are to be fitted with handrails and are to be securely attached to the unit's structure.

1.5.4 The dimensions of vertical access openings in wash tank bulkheads are to be sufficient to allow the passage of one person wearing a self-contained air breathing apparatus. The minimum clear opening is not to be less than 600 mm by 800 mm with a height of not more than 600 mm from the bottom shell plating unless gratings or other footholds are provided.

1.5.5 Aluminium is not permitted for the construction of tank covers. The possible use of reinforced fibreglass covers is to be specially examined by the Society.

1.5.6 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 units 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 unit's movements and accelerations (considering applicable environmental conditions for loading/unloading operations) are to be considered with respect to the vessel's available margin of positive initial stability (GMo).

Where the gutter bars installed are higher than 300 mm, they are to be treated as bulwarks with freeing ports arranged and provided with effective closures for use during loading and discharge operations. Attached closures are to be arranged in such a way that jamming is prevented while at sea, enabling the freeing ports to remain effective.

On units without deck camber, or where the height of the installed gutter bars exceeds the camber, and for units having cargo tanks exceeding 60% of the unit's maximum beam amidunits regardless of gutter bar height, gutter bars may not be accepted without an assessment of the initial stability (GMo) for compliance with the relevant intact stability requirements taking into account the free surface effect caused by liquids contained by the gutter bars.

1.6 Other compartments

1.6.1 Notwithstanding [1.1.1], access to double bottom tanks is permitted from a pump room, a cargo pump room, a cofferdam or a pipe tunnel or even, under reserve of the agreement of the Society, from a segregated ballast tank.

1.6.2 The pipe tunnels are to comply with the following requirements:

- they are not to communicate with the machinery room where the prime movers of the cargo pumps are located
- 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.

Where there is permanent access from a pipe tunnel to the cargo pump room, a watertight door complying with the requirements of Pt B, Ch 1, Sec 4 and in addition with the following:

- the watertight door is to be capable of being manually closed from outside the main cargo pump room entrance
- the watertight door is to be kept closed during normal operations of the unit except when access to the pipe tunnel is required.

Note 1: A warning notice is to be affixed to the door in order to avoid to be left open.

Pipes tunnel are to be suitable ventilated.

1.6.3 Horizontal access openings, hatches or manholes are to be of sufficient size to allow the free passage of one person wearing a self-contained air breathing apparatus. The clear opening, unless otherwise authorised by the Society, is to be at least equivalent to a circle of 600 mm in diameter.

1.6.4 The minimum clear opening for vertical access is not to be less than 600 mm by 800 mm, unless otherwise authorised by the Society.

1.6.5 Unless other additional arrangements (considered satisfactory by the Society), are provided to facilitate their access, the double bottom tanks are to be provided with at least two separate means of access, in compliance with [1.1.1] and [1.6.1].

1.6.6 Notwithstanding [1.1.1], access manholes to spaces at the non manned end of the unit classed as hazardous areas are permitted from an enclosed gas safe space, provided that their closing means are gastight and that a warning plate is provided in their vicinity to indicate that the opening of the manholes is only permitted after checking that there are no flammable gases inside the compartment in question.

1.7 Spaces at non-manned end of the unit-air locks

1.7.1 The enclosed spaces located at the non manned end of the unit, below the forecastle deck, if any, are not considered in general as hazardous areas, provided they are separated by an air lock from hazardous areas on the open deck.

Note 1: Such an agreement is, in general, only permitted for spaces opposite to accomodation block. In case such an agreement is considered for spaces other than the spaces opposite to accomodation block, it is to be specially examined by the Society.

Note 2: attention is drawn to the fact that such an arrangement may not be allowed by certain national regulations.

1.7.2 An air lock is to comprise two steel doors sufficiently gastight spaced at least 1,5 m but not more than 2,5 m apart. The doors are to be of the self-closing type and without any holding back arrangements.

1.7.3 The air lock is to be mechanically ventilated from a gas safe space and maintained at an overpressure of 0,25 mbar minimum compared to the hazardous area on the open weather deck in accordance with the general provisions of Pt C, Ch 4, Sec 3, [5], and at a lower pressure than that maintained in the protected space which is itself to be ventilated by a mechanical ventilation system with an air renewal rate at least 12 changes per hour.

1.7.4 If the spaces opposite to accommodation block, protected by the same air lock, include several rooms, some of the rooms need not be mechanically ventilated if they are separated from the air lock by a mechanically ventilated space and by a self-closing sufficiently gastight steel door.

1.7.5 The air lock may have more than two doors, in which case, the arrangements stated in [1.7.2] relating to the spacing of the internal and external doors are not required. The arrangement of such an air lock is to be to the satisfaction of the Society.

1.7.6 It is reminded that, in accordance with Part C, Chapter 4, the store for paints is to be fitted with certified safe lighting irrespective of their arrangement.

1.7.7 The ventilation system provided for the air lock and the protected space(s) is to be capable of being controlled from outside the air lock and these spaces. A warning plate is to be provided at the entrance of the air lock indicating that the ventilation is to be switched on at least 15 min. before entering the space.

An audible and visual alarm is to be provided to indicate that the external door of the air lock is moved from the closed position when the ventilation system of the air lock or the protected space(s) is stopped, or in case of loss of the positive pressure required in [1.7.3], between the hazardous area on the open deck and the protected spaces.

2 Cargo and slop tanks venting, inerting, purging and gas-freeing

2.1 Cargo and slop tanks venting

2.1.1 Principle

Cargo tanks are to be provided with venting systems entirely distinct from the air pipes of the other compartments of the unit. 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.

2.1.2 Design of ventings arrangements

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 unloading or ballasting

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 item b). Alternatively, pressure sensors may be fitted in each tank protected by the arrangement required in item b), with a monitoring system in the unit'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.

Note 1: A pressure/vacuum breaker fitted on the inert gas main may be utilised as the required secondary means of venting. Where the venting arrangements are of the free flow type and the masthead isolation valve is closed for the unloading condition, the inert gas system will serve as the primary underpressure protection with the pressure/vacuum breaker serving as the secondary means.

2.1.3 Combination of venting arrangements

The venting arrangements in each cargo tank may be independent or combined with other cargo tanks and may be incorporated into the inert gas piping.

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 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 [2.1.2].

Note 1: Inadvertent closure or mechanical failure of the isolation valves need not be considered in establishing the secondary means of venting cargo tanks required in [2.1.2].

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 [2.1.2].

2.1.4 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 unit. 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.

2.1.5 Openings for pressure release

Openings for pressure release required by [2.1.2] 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.

Note 1: The provisions of item a) are not applicable to the pressure/vacuum breaker fitted on the inert gas main (see Note 1 of [2.1.2]) provided its settings are above those of the venting arrangements required by items a) and b) of [2.1.2].

Note 2: If provided, Anchor windlass and chain locker openings constitute an ignition hazard. They are to be located at the distances required by item b) above.

2.1.6 Pressure/vaccum valves

a) Pressure/vacuum valves are to be set at a positive pressure not exceeding 0,021 N/mm^2 and at a negative pressure not exceeding 0,007 N/mm^2.

Note 1: Higher setting values not exceeding 0,07 N/mm^2 may be accepted in positive pressure if the scantlings of the tanks are appropriate.

b) Pressure/vacuum valves required by [2.1.2] 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.

c) Pressure/vacuum valves are to be of a type approved by the Society.

d) Pressure/vacuum valves are to be readily accessible.

e) 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.

2.1.7 Vent outlets

Vent outlets for cargo loading, unloading and ballasting required by [2.1.2] are:

a) to permit:
   1) the free flow of vapour mixtures, or
   2) the throttling of the discharge of the vapour mixtures to achieve a velocity of not less than 30 m/s

b) to be so arranged that the vapour mixture is discharged vertically upwards

c) to be, where the method is by free flow of vapour mixtures, 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 and equipment which may constitute an ignition hazard

d) to be, where the method is by high velocity discharge, 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 constitute an ignition hazard. These outlets are to be provided with high velocity devices of a type approved by the Society

e) to 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.

Note 1: The height requirements of items c) and d) above are not applicable to the pressure/vacuum breaker fitted on the inert gas main (see Note 1 of [2.1.2]) provided its settings are above those of the venting arrangements required by items a) and b) of [2.1.2].

Note 2: If provided, anchor windlass and chain locker openings constitute an ignition hazard. They are to be located at the distances required by items c) and d) above.

2.1.8 High velocity valves

a) High velocity valves are to be readily accessible.

b) High velocity valves not required to be fitted with flame arresters (see [2.1.9]) are not to be capable of being locked on open position.

2.1.9 Prevention of the passage of flame into tanks

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 shall be to the satisfaction of the Society for compliance with IMO MSC Circular 677.

Note 1: The above requirement is not applicable to the pressure/vacuum breaker fitted on the inert gas main (see Note 1 of [2.1.2]) provided its settings are above those of the venting arrangements required by items a) and b) of [2.1.2].

Note 2: Attention is to be provided to additional tests required for detonation flame arrestors located in line.

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.

2.1.10 Prevention of liquids rising in the venting system

a) Provisions are to be made to prevent liquid rising in the venting system (refer to Ch 1, Sec 12, [6.2]).

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.

2.1.11 Additional provisions for units fitted with an overflow system

a) On units fitted with an inert gas system, one or more pressure/vacuum-breaking devices are to be provided to prevent the cargo tanks from being subject to:

   1) 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 are left shut, and

   2) 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.

b) The location and design of the devices referred to in item a) above are to be in accordance with requirements [2.1.1] to [2.1.10].

2.2 Cargo and slope tanks inerting, purging and/or gas-freeing crude oil tanks

2.2.1 General

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 [2.2.2] and [2.2.3], as applicable, are to be complied with.

b) The arrangements for inerting, purging or gas-freeing of empty tanks as required in Ch 1, Sec 12, [4] are to be to the satisfaction of the Society and are to be such that the accumulation of hydrocarbon vapours in pockets formed by the internal structural members in a tank is minimized.

c) Ventilation/gas-freeing lines between fans and cargo tanks are to be fitted with means, such as detachable spool pieces, to prevent any back-flow of hydrocarbon gases through the fans when they are not used.

d) 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.

2.2.2 Units provided with an inert gas system

The following provisions apply to units provided with an inert gas system:

a) On individual cargo tanks the gas outlet pipe, if fitted, is to be positioned as far as practicable from the inert gas / air inlet and in accordance with [2.2.2]. The inlet of such outlet pipes may be located either at the deck level or at not more than 1 m above the bottom of the tank.

b) The cross-sectional area of such gas outlet pipe referred to in a) above is to be such that an exit velocity of at least 20 m/s can be maintained when any three tanks are being simultaneously supplied with inert gas. Their outlets are to extend not less than 2 m above deck level.

c) Each gas outlet referred to in b) above is to be fitted with suitable blanking arrangements.

d) The arrangement of inert gas and cargo piping systems is to comply with the provisions of Ch 1, Sec 12, [4.4.7], item f).

e) The cargo tanks are first to be purged in accordance with the provisions of a) to d) above 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.

2.2.3 Units not provided with an inert gas system

When the unit 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 [2.1.7], 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.

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.

3 Cargo tanks vents recovery system

3.1 General

3.1.1 Application

This system may be fitted to boost cargo gas or vapour mixture to the process or low pressure (LP) flare system in lieu of sending them to the standard cargo venting system.

3.1.2 The acronym COTVR stands for Cargo Tanks Vents Recovery.

3.1.3 The COTVR system is to be designed, constructed and tested to the satisfaction of the Society.

3.1.4 Throughout the present, the term "crude oil tanks" includes also slop tanks.

3.1.5 Detailed instruction manuals are to be provided on board, covering the operations, safety and maintenance requirements and occupational health hazards relevant to the COTVR system and its application to the cargo tanks system. The manuals are to include guidance on procedures to be followed in the event of a fault or failure of the COTVR system.

3.1.6 The following documents are to be submitted for review:

- process and Instrumentation diagrams of the COTVR system and of its connection to the cargo tanks system, to the IG system, to the HC blanket gas system, if any, and to the flare system
- cause and effect diagram for the system
- settings of the pressure / vacuum protection devices
- HAZID and HAZOP studies of the system.

3.1.7 Piping, fittings and mechanical parts of this COTVR system are to comply with the relevant requirements of Part C, Chapter 1.

3.1.8 Equipment must be suitable for the hazardous area where they are located.

3.1.9 The COTVR system is to remain within the cargo area.

3.1.10 The limit of the scope of Classification (without **PROC** notation) is generally downstream the COTVR at the isolation valve referred to in [3.5.4].

3.1.11 Depending on findings of the HAZOP studies, the Society may raise additional requirements.

3.2 Capacity

3.2.1 The system is to be capable of boosting cargo tank vents to the process or LP flare system at a rate of at least 100 per cent of the maximum loading capacity of the unit expressed as a flow rate.

3.3 Materials and constructive measures

3.3.1 Those parts of piping, fittings, recovery equipment, blowers, filters, non-return devices and other drain pipes which may be subjected to corrosive action of the gases and/or liquids are to be either constructed of corrosion resistant material or lined with rubber, glass fibre epoxy resin or other equivalent coating material.

3.3.2 Constructive measures are to be taken to minimize the risk of ignition from generation of static electricity by the system itself.

3.4 Filters

3.4.1 Filters or equivalent devices are to be fitted to minimize the amount of water carried over to the cargo tanks vents recovery equipment.

3.5 COTVR piping system

3.5.1 Branch piping from each cargo tank should be connected to the COTVR main. This branch piping is to be fitted with either stop valves or equivalent means of control for isolating each tank. Where stop valves are fitted, they are to be provided with a control system to indicate the operational status of such valves.

In case of COTVR is connected to the dirty inert gas header, above referred valves may be the ones of the IG system. Isolation mean as per below [3.5.3] is nevertheless to be provided.

3.5.2 Piping systems are to be so designed as to prevent the accumulation of cargo or water in the pipelines under all normal conditions.

3.5.3 Arrangements are to be made to ensure an effective isolation of the COTVR system from the upstream systems (cargo tanks/cargo venting/Inert gas/HC blanket gas systems). This may consist in a fast closing shut-down valve.

3.5.4 Arrangements are to be made to ensure an effective isolation of the COTVR system from the downstream systems (process systems/LP flare system). This may consist in a fast closing shut-down valve.

3.5.5 The COTVR system is to be so designed that the minimum and maximum pressures which it can exert on any cargo tank will not exceed the test pressures of any cargo tank.

3.6 Instrumentation

3.6.1 A pressure device to regulate the capacity of the recovery equipment or a gas regulating valve is to be fitted.

3.6.2 Devices and alarms are to be provided for continuously recording and indicating:

a) The temperature and pressure upstream the shutdown valve mentioned in [3.5.3].

b) The temperature and pressure downstream the shutdown valve mentioned in [3.5.4].

c) The pressure of the cargo gas at the suction side of the gas recovery equipment, whenever the COTVR recovery equipment is operating.

d) The temperature and pressure of the cargo gas at the discharge side of the gas recovery equipment, whenever the COTVR recovery equipment is operating.

e) The oxygen content on the discharge side of the gas recovery equipment.

f) The failure of the recovery equipment.

g) The water level in the filter(s) mentioned in [3.4].

3.6.3 The alarms referred to in [3.6.2] are to be fitted in the machinery space and cargo control room, where provided, but in each case in such a position that they are immediately received by responsible members of the crew.

3.7 Safeguards

3.7.1 All the requirements of the present sub-article [3.7] may be adapted based on the findings and conclusions of the HAZOP report.

3.7.2 Automatic shutdown of the recovery equipment and of the shutdown valve mentioned in [3.5.3] is to be arranged on predetermined limits being reached in respect of [3.6.2] item a) (low pressure or high temperature), item b) (low) and item d) (high pressure or temperature).

3.7.3 Automatic shutdown of the recovery equipment and of the shutdown valves mentioned in [3.5.4] is to be arranged in respect of [3.6.2] item e), when the oxygen content exceeds 5% by volume.

Automatic shutdown of the shutdown valve mentioned in [3.5.4] is to be arranged in respect of [3.6.2] item b) (high pressure).

3.7.4 Automatic shutdown of the shutdown valve mentioned in [3.5.3] is to be arranged in respect of [3.6.2] item f).

3.7.5 Automatic shutdown of the recovery equipment is to be arranged on predetermined limits being reached in respect o [3.6.2] item g) (high water level).

3.7.6 Automatic shutdown of the recovery equipment and of the shutdown valve mentioned in [3.5.4] is to be arranged on predetermined limits being reached in respect of [3.6.2] item d) (high).

SECTION 11 EQUIPMENT AND SAFETY PARTICULARS

1 General

1.1

1.1.1 The equipment is to comply with the applicable National Rules and, for items covered by classification, with requirements of Part C.

The present Section gives particular requirements to be met in addition to Part C requirements.

2 Hazardous areas

2.1 General

2.1.1 The present [2] is applicable to hazardous areas due to cargo storage.

For hazardous areas due to other causes refer to Part C, Chapter 4.

2.1.2 For definitions used in the present [2], refer to Pt C, Ch 4, Sec 3.

2.1.3 Attention is drawn on the fact that provisions of IMO Regulations for hazardous areas of oil tankers and liquefied gas carriers, as well as those of the Ship Rules applicable to the same, are applicable to units intended to receive a combination of service and structural type notations including **oil tanker (or liquefied gas carrier) / offshore service ship**.

2.2 Classification of hazardous areas due to oil storage and offloading

2.2.1 For the purpose of machinery and electrical installations, hazardous areas are classified as in [2.2.2] to [2.2.4].

2.2.2 Hazardous area zone 0 are the interiors of cargo tanks, slop tanks, any pipework of pressure-relief or other venting systems for cargo and slop tanks, pipes and equipment containing the cargo or developing flammable gases or vapours.

2.2.3 Hazardous areas zone 1 are:

a) void spaces adjacent to, above or below, integral cargo tanks
b) hold spaces containing independent cargo tanks
c) cofferdams and permanent (for example, segregated) ballast tanks adjacent to cargo tanks
d) cargo pump rooms
e) enclosed or semi-enclosed spaces, immediately above cargo tanks (for example, between decks) or having bulkheads above and in line with cargo tank bulkheads, unless protected by a diagonal plate acceptable to the Society
f) enclosed or semi-enclosed spaces immediately above cargo pump rooms or above vertical cofferdams adjacent to cargo tanks, unless separated by a gas-tight deck and suitable ventilated
g) spaces, other than cofferdams, adjacent to and below the top of a cargo tank (for example, trunks, passageways and holds)
h) areas on open deck, or semi-enclosed spaces on open deck, within 3 meters of any cargo tank outlet, gas, vapour outlet (see Note 1 below), 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

Note 1: Such areas are, for example, all areas within 3 meters of cargo tank hatches, sight ports, tank cleaning opening, ullage openings, sounding pipes, cargo vapour outlets.

i) 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 unloading and ballasting (for example flare facility), within a vertical cylinder of unlimited height and 6 meters radius centred upon the centre of the outlet, and within a hemisphere of 6 meters radius below the outlet
j) areas on open deck, or semi-enclosed spaces on open deck within 1,5 meters of cargo pump room entrances, cargo pump room ventilation inlet, openings into cofferdams or other zone 1 space
k) areas on open deck within 3m spillage coamings surrounding cargo manifold connections
l) areas on open deck over all the cargo (including all ballast tanks within the cargo tank area) where structures are restricting the natural ventilation and to the full breath of the unit plus 3 meters fore and aft of the forward-most cargo tank and aft of the aft-most cargo tank bulkhead, up to a height of 2,4 meters above the deck
m) compartments for cargo hoses
n) enclosed or semi-enclosed spaces in which pipes containing cargoes are located.

2.2.4 Hazardous areas zone 2 are:

a) areas of 1,5 meters surrounding the zone 1 spaces defined in [2.2.3] item h)
b) spaces 4 meters beyond the cylinder and 4 meters beyond the sphere defined in [2.2.3] item i)
c) areas in open deck extending to the coaming fitted to keep any spills on deck and away from the accommodation and service areas and 3 meters beyond these up to a height of 2,4 meters above the deck

d) areas on open deck over all the cargo and slop tanks (including all ballast tanks within the cargo tank area) where unrestricted natural ventilation is guaranteed and to the full breath of the unit plus 3 meters fore and aft of the forward-most cargo tank and aft of the aft-most cargo tank bulkhead, up to a height of 2,4 meters above the deck, surrounding open or semi-enclosed spaces of zone 1

e) spaces forward of the open deck areas to which reference is made to [2.2.3] item l) and [2.2.4] item d), below the level of the main deck, and having an opening on to the main deck or at a level less than 0,5 meters above the main deck, unless the entrance to such spaces do not face the cargo tank area and, together with all other openings to the spaces, including ventilating system inlets and exhausts, are situated at least 5 meters away from the foremost or aftermost cargo tank and at least 10 meters measured horizontally away from any cargo tank outlet and gas outlet and the spaces are mechanically ventilated.

3 Ventilation

3.1 General

3.1.1 Requirements of Pt C, Ch 4, Sec 3, [5] are to be complied with.

4 Electrical installations

4.1 General

4.1.1 Electrical installations for Production, Storage and Offloading Surface Units are to comply with Part C, Chapter 2 and Part C, Chapter 3.

5 Machinery

5.1 General

5.1.1 As a general rule, internal combustion engines are to be avoided as far as possible inside hazardous areas. Nevertheless, the Society may permit fitting of internal combustion engines inside hazardous areas provided it is satisfied with their safety type accordingly to Pt C, Ch 4, Sec 3, [6].

6 Fire protection

6.1 General

6.1.1 Particular provisions of the present Article are in addition to the provision of Part C which remains applicable, except otherwise justified.

6.1.2 The fire protection of the storage area is to be provided by a fixed foam fire extinguishing system complying with [6.5].

6.1.3 For units fitted with bow or stern cargo transfer installations, refer to [6.2.5] and Ch 1, Sec 12, [7] for the protection of the corresponding zones.

6.2 Passive fire protection

6.2.1 As a general rule, requirements of Part C, Chapter 4 are applicable. Nevertheless, Tab 1 and Tab 2 for fire integrity of bulkheads and decks are to replace Pt C, Ch 4, Sec 4, Tab 1 and Pt C, Ch 4, Sec 4, Tab 2.

Definitions of fire categories of the spaces are those given in Pt C, Ch 4, Sec 4, [1.2.2] item b), plus the following one:

(12) Cargo pump room: a space containing cargo pumps and entrances and trunks to such spaces.

6.2.2 Entrances, air inlets and openings to accommodation spaces, service spaces, control spaces and machinery spaces are not to face the storage area. They are to be located on the transverse bulkhead not facing the storage area or on the outboard side of the superstructure or deckhouse at a distance equal to at least 4% of the unit's length but not less than 3 m from the end of the superstructure or deckhouse facing the storage area. This distance, however, need not exceed 5 m.

6.2.3 The Society may permit access doors in boundary bulkheads facing the storage area or within the 5 m limits specified in [6.2.2], to main cargo stations and to such service spaces as provision rooms, store rooms and lockers, provided they do not give access directly or indirectly to any other spaces containing or provided for accommodation, control stations or service spaces such as galleys, pantries or workshops, or similar spaces containing sources of vapour ignition. The boundary of such space is to be insulated to “A-60” standard, with the exception of the boundary facing the storage area. Bolted plates for the removal of machinery may be fitted within the limits specified in [6.2.2].

Note 1: An access to a deck foam system room (including the foam tank and the control station) can be permitted within the limits mentioned in [6.2.2], provided that the conditions listed in [6.2.3] are satisfied and that the door is located flush with the bulkhead.

6.2.4 Windows and sidescuttles facing the storage area and the sides of the superstructures and deckhouses within the limits specified in [6.2.2] are to be of non-opening type. Such windows and sidescuttles are to be constructed of “A-60” class standard.

6.2.5 When a loading or offloading connection is provided at the manned end of the unit, entrances, air inlets and openings to accommodation spaces, service and machinery spaces and control stations are not to face the cargo transfer connection location. They are to be located on the outboard side of the superstructure or deckhouse at a distance equal to at least 4% of the unit's length but not less than 3 m from the end of the superstructure or deckhouse facing the connection. This distance, however, need not exceed 5 m.

Sidescuttles facing the connection location and on the side of the superstructure or deckhouse within the distance mentioned above are to be of the non-opening type. In addition, during the use of the transfer arrangements, all doors, ports and other openings on the corresponding superstructure or deckhouse side are to be kept closed.

Air pipes and other openings to enclosed spaces not listed above are to be shielded from any spray which may come from a burst hose or connection.

Table 1 : Fire integrity of bulkheads separating adjacent spaces

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Control stations	(1)	A-0 [d]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*	A-0	A-60
Corridors	(2)		C	B-0	A-0 [b]	B-0	A-60	A-0	A-0	A-0	*	B-0	A-60
Accommodation spaces	(3)			C	A-0 [b]	B-0	A-60	A-0	A-0	A-0	*	C	A-60
Stairways	(4)				A-0 [b]	A-0 [b]	A-60	A-0	A-0	A-0	*	A-0 [b]	A-60
Service spaces (low risk)	(5)					C	A-60	A-0	A-0	A-0	*	B-0	A-60
Machinery spaces of category A	(6)						* [a]	A-0 [a]	A-60	A-60	*	A-0	A-0
Other machinery spaces	(7)							A-0 [a] [b]	A-0	A-0	*	A-0	A-0
Hazardous areas	(8)								–	A-0	*	A-0	A-0
Service spaces (high risk)	(9)									A-0 [c]	*	A-0	A-60
Open decks	(10)										–	*	*
Sanitary and similar spaces	(11)											C	A-60
Cargo pump room	(12)												*

[a] : Where the space contains an emergency power source or components of an emergency power source that adjoins a space containing a unit's service generator or the components of a unit's service generator, the boundary bulkheads between those spaces is to be “A-60” class division.

[b] : Except otherwise accepted in Part C, Chapter 4.

[c] : Where spaces are of the same numerical category and superscript (c) appears, a bulkhead of the rating shown in the tables is only required when the adjacent spaces are for a different purpose e.g. in category (i). A galley does not require a bulkhead but a galley next to a paint room requires an “A-0” bulkhead.

[d] : Bulkheads separating the navigating bridge, chartroom and radio room from each other may be “B-0” rating.

Note 1: When an asterisk appears in the table, the division is required to be of steel or equivalent material but not required to be of "A" class standard. However, where a deck is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flame and smoke.

6.2.6 The location and arrangement of the galleys are to be such that there is a minimum risk of fire.

Air intakes and air outlets of machinery spaces are to be located as far aft as practicable and, in any case, outside the limits specified in [6.2.2].

6.3 Fire water pumps

6.3.1 The requirements of Pt C, Ch 4, Sec 6 relative to fire water pumps and mains are applicable, together with additional requirements of [6.3.2] and [6.3.3].

6.3.2 Within the storage area, isolation valves are to be fitted in the fire main at intervals of not more than 40 m to preserve the integrity of the fire main system in case of fire or explosion.

6.3.3 Operation of a deck foam system at its required output is to permit the simultaneous use of the minimum required number jets of water at the required pressure from the fire main and the process deluge system if any.

6.4 Cargo pump rooms

6.4.1 Each cargo pump room is to be provided with a fixed fire extinguishing system operated from a readily accessible position outside the pump room.

6.4.2 The fixed fire extinguishing system required in [6.4.1] is to be one of the following fixed fire-extinguishing systems operated from a readily accessible position outside the cargo pump room. Cargo pumps room are to be provided with a system suitable for machinery spaces of category A:

Table 2 : Fire integrity of decks separating adjacent spaces

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Control stations	(1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-0	*	A-0	XXX
Corridors	(2)	A-0	*	*	A-0	*	A-60	A-0	A-0	A-0	*	*	XXX
Accommodation spaces	(3)	A-60	A-0	*	A-0	*	A-60	A-0	A-0	A-0	*	*	XXX
Stairways	(4)	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0	A-0	*	A-0	XXX
Service spaces (low risk)	(5)	A-15	A-0	A-0	A-0	*	A-60	A-0	A-0	A-0	*	A-0	XXX
Machinery spaces of category A	(6)	A-60	A-60	A-60	A-60	A-60	* [a]	A-60	A-60	A-60	*	A-0	XXX
Other machinery spaces	(7)	A-15	A-0	A-0	A-0	A-0	A-0 [a]	* [a]	A-0	A-0	*	A-0	XXX
Hazardous areas	(8)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	–	A-0	–	A-0	A-0
Service spaces (high risk)	(9)	A-60	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-0	*	A-0	XXX
Open decks	(10)	*	*	*	*	*	*	*	–	*	–	*	XXX
Sanitary and similar spaces	(11)	A-0	A-0		A-0		A-0	A-0	A-0	A-0	*	*	XXX
Cargo pump room	(12)	XXX	XXX	XXX	XXX	XXX	A-0	A-0	A-0	A-0	*	–	*

[a] : Where the space contains an emergency power source or components of an emergency power source that adjoins a space containing a unit's service generator or the components of a unit's service generator, the boundary bulkheads between those spaces is to be "A-60" class division.

[b] : Where spaces are of the same numerical category and superscript (c) appears, a bulkhead of the rating shown in the tables is only required when the adjacent spaces are for a different purpose e.g. in category (i). A galley does not require a bulkhead but a galley next to a paint room requires an "A-0" bulkhead.

Note 1: When an asterisk appears in the table, the division is required to be of steel or equivalent material but not required to be of "A" class standard. However, where a deck is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations are to be made tight to prevent the passage of flame and smoke.

Note 2: "XXX" in the cells indicates that corresponding vicinities are prohibited.

- either a carbon dioxide or another extinguishing medium system complying with the applicable provisions of Pt C, Ch 4, Sec 11, [4] and with the following:
  - the audible signal mentioned in Pt C, Ch 4, Sec 11, [4.1.1] item b)2), if of electrical type, is to be of certified safe type. A light signal is not required but, if it is provided, it is also to be of a certified safe type

    When the audible signal is of pneumatic type, it must not be activated by the fire extinguishing medium but by clean dry air
  - a notice is to be exhibited at the controls stating that, due to the electrostatic ignition hazard, the system is to be used only for fire extinguishing and not for inerting purposes, or
- a high expansion foam system complying with the provisions of Pt C, Ch 4, Sec 11, [5.1.2], provided that the foam concentrate supply is suitable for extinguishing fires involving the cargo stored, or
- a fixed pressure water-spraying system complying with Pt C, Ch 4, Sec 11, [6.1.1] or Pt C, Ch 4, Sec 11, [6.1.2].

6.4.3 Where the extinguishing medium used in the crude oil pump room system is also used in systems serving other spaces, the quantity of medium provided or its delivery rate need not be more than the maximum required for the largest compartment.

6.4.4 Two portable foam extinguishers or equivalent are to be provided for each pump room; one is to be fitted near the pumps and the other near the access to the pump room.

6.5 Fixed deck foam system

6.5.1 Definitions

a) An applicator is a hose and nozzle that can be held and directed by hand.

b) A foam solution is a homogeneous mixture of water and foam concentrate in the proper proportions.

6.5.2 Principles

a) The arrangements for providing foam are to be capable of effectively delivering foam solution to the entire storage area as well as into any cargo tank when the deck has been ruptured.

b) The deck foam system is to be capable of simple and rapid operation.

c) Operation of a deck foam system at its required foam solution flow rate shall still permit the simultaneous use of the minimum required number of jets of water at the required pressure provided by the fire main system.

Note 1: A common line for fire main and deck foam line can only be accepted if it can be demonstrated that the hose nozzles can be effectively controlled by one person when supplied from the common line at a pressure needed for operation of the monitors.

Additional foam concentrate is to be provided for operation of the 2 hydrants for the same period of time required for the foam system.

The simultaneous use of the minimum required jets of water is to be possible on deck over the full length of the unit, in the accommodation spaces, service spaces, control stations and machinery spaces.

d) Foam from the fixed foam system is to be supplied by means of monitors and/or deluge system and foam applicators.

e) Foam applicators are to be provided to ensure flexibility of action during fire-fighting operations and to cover areas screened and/or deluge system.

6.5.3 Foam solution – Foam concentrate

a) The supply rate of the foam solution is not to be less than the greatest of the following:

   1) 0,6 l/min/m² of storage deck area, where storage deck area means the maximum breadth of the unit multiplied by the total longitudinal extent of the cargo and slop tank spaces

   2) 6 l/min/m² of the horizontal sectional area of the single tank having the largest such area

   3) 3 l/min/m² of the horizontal sectional area of group of tanks to be protected simultaneously as defined by the worst case fire scenario

   4) If the fixed deck foam system is ensured by an arrangement of monitors, 3 l/min/m² of the area protected by the largest monitor, such area being entirely forward of the monitor, but not less than 1250 l/min.

b) Sufficient foam concentrate is to be supplied to ensure at least 20 min. of foam generation on storage units fitted with an inert gas installation or at least 30 min. of foam generation on storage units not fitted with an inert gas installation when using solution rates stipulated in item a) above, whichever is the greatest.

c) The foam expansion ratio (i.e. the ratio of the volume of foam produced to the volume of mixture of water and foam-making concentrate supplied) is not generally to exceed 12 to 1. Where systems essentially produce low expansion foam but at an expansion ratio slightly in excess of 12 to 1 the quantity of foam solution available is to be calculated as for 12 to 1 expansion ratio systems. When medium expansion ratio foam (between 50 to 1 and 150 to 1 expansion ratio) is employed, the application rate of the foam and the capacity of a monitor installation is to be to the satisfaction of the Society.

d) The water supply to this fixed deck foam system shall be of a quality so that adverse effects on foam formation, stability or performances do not occur.

e) The foam concentrate is to be of a type approved by the Society and is to be suitable for this use (with regards to the intended cargo contained in the protected cargo tanks, a particular attention is to be given to the possible need of alcohol resistant foam).

6.5.4 Monitors, nozzles of deluge systems and applicators

a) When an arrangement of monitor is provided, at least 50 per cent of the foam solution supply rate required in items a)1) and a)2) of [6.5.3] is to be delivered from each monitor.

b) When an arrangement of monitor is provided, the capacity of any monitor is to be at least 3 l/min. of foam solution per square meter of the deck area protected by that monitor, such area being entirely forward of the monitor. Such capacity is not to be less than 1250 l/min.

c) The capacity of any applicator is to be not less than 400 l/min. and the applicator throw in still air conditions is not to be less than 15 m.

Note 1: The flow delivered from one applicator shall be limited by the reaction force at the working pressure that one operator can withstand. As a recommendation, the applicator reaction usually limits the solution flow to about 1150 l/min.

d) Foam applicators, nozzles and monitors are to be of a type approved by the Society.

6.5.5 Arrangement and installation

a) The foam concentrate is to be stored in an accessible location unlikely to be damaged in the event of fire or explosion and not having direct opening or exposure to the protected areas.

b) The arrangement of the deck foam system ducting shall be such that a fire or explosion in the protected areas will not affect the foam generating equipment.

c) Monitors

   1) The number and position of monitors are to be such as to comply with [6.5.3] item a).

   2) The area protected by a monitor is considered located entirely forward of the monitor.

   3) The distance from the monitor to the farthest extremity of the protected area forward of that monitor is not to be more than 75% of the monitor throw in still air conditions.

   4) A monitor and hose connection for a foam applicator are to be situated both port and starboard at the front of the accommodation spaces facing the storage area.

   5) The number of foam applicators provided is not to be less than four. The number and disposition of foam main outlets is to be such that foam from at least two applicators can be directed on to any cargo tank deck area.

d) Deluge systems

   1) The number and position of foam nozzles are to be such as to comply with [6.5.2].

   2) The foam deluge system may be separated in several sections by means of remote control stop valves.

3) A coaming of a sufficient height is to be provided on the cargo tank deck in order to avoid the spillage of flammable liquids. This coaming should be in line with the fire zones identified during the fire scenario analysis mentioned in [6.5.3] item a)3).

Note 1: For the design of the fire zones, reference is made to the provisions of NFPA 101 and 101A code.

e) Isolation valves are to be provided in the foam main, and in the fire main when this is an integral part of the deck foam system, immediately forward of any monitor position to isolate damage section of those mains.

f) The main control station for the system is to be suitably located outside the storage area, adjacent to the accommodation spaces and readily accessible and operable in the event of a fire in the areas protected.

6.6 Emergency and offloading control station

6.6.1 At least one emergency control station is to be provided, at a suitable manned location outside hazardous areas.

If two emergency control stations are provided, the second one is to be placed at the same location as the loading control station.

6.6.2 Offloading control stations are to be provided with all necessary instruments for safe and easy operation of handling systems, fully independent from instruments necessary for propulsion (if any) and operation of auxiliary engines.

These control stations are to be permanently fitted with:

- indicators showing if remote controlled valves are closed or open
- means of communication with open deck, pump room(s), machinery spaces and control room.

Besides which, indicators showing if valves are closed or open are to be fitted on all locally manoeuvrable valves.

7 Life saving appliances

7.1 Life saving appliances

7.1.1 In addition to requirements of Pt C, Ch 4, Sec 12 applicable for units intended to receive LSA additional class notation, lifeboats are to be of a totally enclosed fire resistant type.

SECTION 12 PIPING SYSTEMS

1 General

1.1 Application

1.1.1 Bilge, ballast, scupper, oil fuel, cargo and other piping systems are to comply with the applicable requirements of Part C, Chapter 1 and of other documents referred to in this Chapter; requirements of the present Section are additional ones.

1.1.2 Production piping systems are to comply, in addition to requirements of [3], with applicable requirements of the Rule Note NR 459 "Process systems on board offshore units and installations".

1.2 Separation of systems

1.2.1 Piping systems carrying non-hazardous fluids are generally to be separate from piping systems which may contain hazardous fluids. Cross connection of the piping systems may be permitted where means for avoiding possible contamination of the non-hazardous fluid system by the hazardous fluid are provided.

2 Bilge - Ballast - Oil fuel - Scupper lines

2.1 General

2.1.1 Cargo storage tanks are not to be used for ballast purposes except in emergency cases; tanks used for cargo storage are not to be served by the ballasting system of the unit, except as provided for throughout the present Section.

2.1.2 Passage through cargo tanks and slop tanks

a) Unless otherwise specified, bilge, ballast and fuel oil systems serving gas safe 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:

   1) they are to have welded or heavy flanged joints the number of which is to be kept to a minimum

   2) they are of extra reinforced wall thickness as per Pt C, Ch 1, Sec 7

   3) they are adequately supported and protected against mechanical damage.

c) Lines of piping which run through cargo tanks are to be fitted with closing devices.

2.1.3 Unless otherwise specified, bilge, ballast and scupper systems serving spaces or compartments situated within the storage area are to be independent from other systems serving spaces or compartments outside the storage area and are not to lead into such spaces.

2.1.4 Oil fuel piping systems are to be independent from the cargo piping system and, unless otherwise authorised by the Society, independent from the ballast piping system. They are not to led through cargo tanks or slop tanks.

2.1.5 As applicable, the forward spaces located forward of the fore cofferdam in gas safe space and, the aftermost spaces located abaft the aft cofferdam in gas safe space, are to be drained in accordance with the applicable requirements of Part C, Chapter 1.

2.1.6 The sea inlets serving the segregated ballast tanks are to be separated from the sea outlets serving the cargo tanks or slop tanks.

2.2 Bilge system

2.2.1 Bilge pumps

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 pump room

a) Arrangements are to be provided to drain the pump rooms by means of power pumps or bilge ejectors.

Note 1: On units 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 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) A high level alarm is to be provided. Refer to item d) of Ch 1, Sec 10, [1.2.6].

2.2.3 Draining of tunnels and pump rooms other than cargo pump rooms

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 [2.2.2], item b).

2.2.4 Draining of cofferdams located at the fore and aft ends of the cargo area

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 (and/or fore as applicable) adjacent to the cargo pump room may be drained by a cargo pump in accordance with the provisions of [2.2.2], items b) and c), or by bilge ejectors.

c) Drainage of the after cofferdam (and/or fore cofferdam as applicable) from the engine room bilge system is not permitted.

Note 1: On units 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

2.2.5 Drainage of cofferdams or void spaces located within the cargo area

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 Segregated ballast tanks within the storage area

2.3.1 Tanks within storage area, intended to be used exclusively for ballast (segregated ballast tanks), are, according to [2.1.3], unless otherwise permitted, to be served by piping and pumping systems independent of cargo and fuel oil piping and pumping systems. 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.

Note 1: 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

Note 2: Where installed in the cargo pump room, ballast pumps are to comply with [3.2.3].

2.3.2 Two distinct pumping means are to be provided for these tanks, one of which at least, is to be mechanically or hydraulically driven or comprising an ejector used exclusively for this purpose. The second may be a portable means.

2.3.3 For emergency deballasting of the segregated ballast tanks located within the storage area, cargo pumps may be used under the following conditions:

- the connection between ballast pumping system and the cargo pump is not to be permanent and to be located as close as possible to the cargo pump suction
- the connection is to comprise a detachable spool piece, a non-return valve to prevent using the pump to fill tanks, and a shut-off valve located on the ballast pipe side.

2.3.4 Where segregated ballast pipes pass through cargo tanks, namely for the application of [2.3.3], they are to be made of steel of reinforced thickness and their connections are to be of the welded type. Connections by means of heavy flanges may nevertheless be permitted provided they are kept to a minimum. Expansion joints are not to be used for that purpose.

Note 1: Sliding type coupling are not to be used for expansion purposes where ballast lines pass through cargo tanks. Expansion bends only are permitted.

2.3.5 For emergency ballasting of the segregated ballast tanks located within the storage area, the use of a pump located outside the storage area is permitted under the conditions that the filling pipe does not pass through cargo tanks and that connection to ballast tanks is made at the top of these tanks and consists in a detachable spool piece and a non-return valve to prevent siphon effects.

2.3.6 Furthermore, for emergency deballasting or ballasting of the segregated ballast tanks located within the storage area, the use of a pump other than a cargo pump is permitted if located within the storage area and if it only serves spaces or compartments located within the storage area.

2.3.7 When the foremost or aftermost cofferdam, located forward or abaft the cargo tanks, are intended for ballasting, they may be emptied by a ballast pump located inside the machinery compartment or the fore spaces whichever the case, provided that the corresponding suction line is directly connected to that pump and not to any of the machinery compartment mains and that the delivery side is directly connected to the unit's side.

2.3.8 Ends of filling pipes serving ballast tanks located within the storage area are to be as near as possible to the bottom of the tanks in order to minimise the risk of generating static electricity.

2.4 Air and sounding pipes

2.4.1

a) 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 deck.

b) The air pipes referred to in a) above are to be arranged as per Part C, Chapter 1 and are to be fitted with easily removable flame screens at their outlets.

c) In offshore units of 600 tons deadweight and above, the air and sounding pipes referred to in a) above are not to pass through cargo tanks except in the following cases:

   1) short lengths of piping serving ballast tanks
   2) lines serving double bottom tanks located within the cargo area, except in the case of oil units of 5 000 tons deadweight and above

   where the following provisions are complied with [2.1.2] b).

2.5 Ballast tanks located outside the storage area (within gas safe zones)

2.5.1 Tanks within gas safe zones, intended to be used exclusively for ballast, are, according to [2.1.3], unless otherwise permitted, to be served by piping and pumping systems independent from piping and pumping systems serving spaces or compartments within the storage area, and corresponding pipes are not to pass through cargo oil or slop tanks.

2.5.2 Requirement [2.5.1] is applicable, without any possible deviation, namely to compartments located abaft (and/or forward as applicable depending on the location of accommodation blocks) the aft (and/or fore) cofferdam.

2.5.3 However, for tanks other than those mentioned in [2.5.2] pumps exclusively dedicated to segregated ballast tanks located within hazardous areas, may be used for ballast tanks located within gas safe zones, on the conditions that there are no common parts in the two circuits other than those needed for this connection to pumps and unit sea chests.

2.5.4 For the emergency deballasting of the ballast tanks located within gas safe zones, other than those covered by [2.5.2], the piping system serving segregated ballast tanks within hazardous areas, may be used, on the condition that the pipe connection to the tank is fitted as near as possible to the tanks by means of a detachable spool piece and a screw-down non return valve preventing the filling of these tanks by this piping system.

2.5.5 Pipes serving ballast tanks located within gas safe zones may, irrespective of the case covered by [2.5.4], pass through cargo tanks, on the condition that [2.3.4] is complied with. Moreover, the thickness of steel pipes is to be at least 16 mm.

2.5.6 Pipes serving ballast tanks located within gas safe zones, other than those covered by [2.5.2], may pass through segregated ballast tanks within hazardous area but expansion joints are not to be used for pipe connections. The possible use of a cargo pump for emergency deballasting of the tanks in question is to be subjected to [2.3.3]

2.5.7 Attention is drawn to the requirements of Part C, Chapter 1 and of other documents referred to in this Chapter relating to the maintenance of the integrity of the watertight subdivision and unit's stability.

2.6 Carriage of ballast in cargo tanks

2.6.1 Every cargo tank is, in general, to be capable of being filled with sea water.

Note 1: Attention is to be provided on the applicable requirements of the MARPOL 73/78 Annex I convention as amended and IMO MEPC Circular 139 (53) for this operation.

2.6.2 Two shut-off valves, at least, are recommended to isolate cargo piping system from sea chests.

2.6.3 Cargo tanks are to be capable of being stripped by two separate means. Cargo pumps may be used for this purpose if their performance characteristics are suitable.

2.6.4 Provisions are to be made, to the Society's satisfaction, to permit efficient draining of tanks at the end of offloading.

2.6.5 The cargo piping system is to be so designed and arranged as to permit efficient cleaning and draining.

2.6.6 The requirements relating to the possible connections between cargo piping system and segregated ballast tank piping system are given in [2.3] and [2.5].

2.6.7 Emergency ballasting of cargo tank may be made by segregated ballast tank pumps on the condition that the connection is made to the top of the tanks and consists of a detachable spool piece and a screw-down valve to prevent siphon effects. The tank filling line is to end as near as possible to the tank bottom in order to reduce the risk of generating static electricity.

2.7 Scupper lines

2.7.1 The passage of scupper pipes or sanitary discharges through cargo tanks is to be avoided as far as practicable. If this is not possible, the number of these pipes is to be reduced to a minimum.

2.7.2 The portions of scupper pipes and sanitary discharges passing through cargo tanks are to be of steel and are to have only welded joints, the number of which is to be kept to a minimum. Furthermore, their thickness is not to be less than 16 mm.

3 Cargo piping and pumping system

3.1 General

3.1.1 A complete system of pumps and piping is to be fitted for handling the cargo oil. Except where expressly permitted, and namely for the bow and stern cargo loading and unloading, 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

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:
   1) in a dedicated pump room, or
   2) on deck, or
   3) when designed for this purpose, within the cargo tanks.

Table 1 : Monitoring of cargo pumps

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
Bearings, temperature	H		visual and audible, in cargo control room or pump control station
Bulkhead shaft gland, 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.

3.2.2 Use of cargo pumps

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

a) Prime movers of cargo pumps are not to be located in the cargo area, except in the following cases:

1) steam driven machine supplied with steam having a temperature not exceeding 220°C

2) hydraulic motors.

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 provisions of Ch 1, Sec 10, [1.2.3] to be complied with.

3.2.4 Design of cargo pumps

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 Tab 1).

3.2.5 Monitoring of cargo pumps

Cargo pumps are to be monitored as required in Tab 1.

3.2.6 Control of cargo pumps

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

Unless otherwise specified, cargo piping is to be designed and constructed according to the requirements of Pt C, Ch 1, Sec 7 applicable to piping systems of class I.

3.3.2 Materials

a) For the protection of cargo tanks carrying crude oil and petroleum products having a flash point not exceeding 60°C, materials readily rendered ineffective by heat are not to be used for valves, fittings, cargo vent piping and cargo piping so as to prevent the spread of fire to the cargo.

b) Cargo piping is, in general, to be made of steel or cast iron.

c) Valves, couplings and other end fittings of cargo pipe lines for connection to hoses are to be of steel or other suitable ductile material.

d) Spheroidal graphite cast iron may be used for cargo oil piping within the double bottom or cargo tanks.

e) Grey cast iron may be accepted for cargo oil lines:

1) within cargo tanks, and

2) 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.

3.3.3 Connection of cargo pipe length

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

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:

1) of an approved type

2) designed to withstand the maximum internal and external pressure

3) electrically conductive.

d) Sliding type couplings are not to be used for expansion purposes where lines for cargo oil pass through tanks for segregated ballast.

3.3.5 Valves with remote control

a) Valves with remote control are to comply with Part C, Chapter 1.

Note 1: All valves provided with a remote control are to be capable of being locally operated.

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

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 5 times the maximum pressure under cargo transfer conditions.

c) Unless bonding arrangements complying with Section 6 are provided, the ohm electrical resistance of cargo hoses is not to exceed 10^6 Ω.

3.4 Cargo piping arrangement and installation

3.4.1 Cargo pipes passing through tanks or compartments

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 [2.1.2], item b).

c) Cargo piping may pass through vertical fuel oil tanks adjacent to cargo tanks on condition that the provisions of [2.1.2], item b) are complied with.

d) Cargo piping passing through cargo tanks is subject to the provisions of MARPOL 73/78 Convention Annex I Regulation 24 (6) as recommended to be applied by IMO MEPC Circular 406.

3.4.2 Cargo piping passing through bulkheads

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

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.

e) Valves are also to be provided where required by the provisions of MARPOL 73/78 Convention Annex I Regulation 24 (5) and (6) as recommended to be applied by IMO MEPC Circular 406.

3.4.4 Prevention of the generation of static electricity

a) In order to avoid the generation of static electricity, the loading pipes are to be led as low as practicable in the tank.

b) Cargo pipe sections and their accessories are to be electrically bonded together and to the unit's hull.

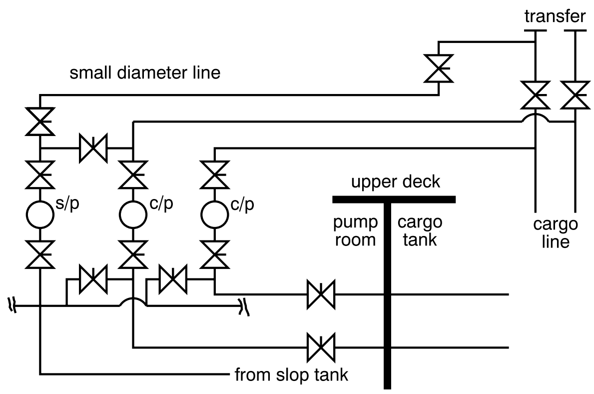
3.4.5 Draining of cargo pumps and cargo lines

Every unit 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 minimized, 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 draining are to be capable of being discharged both by an external transfer and to a cargo tank or a slop tank. For discharge by external transfer, 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 unit'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



3.4.6 Cleaning and gas freeing

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 Sec 12, [4].

4 Inert gas systems

4.1 Application

4.1.1 Units where an inert gas is required

a) Units (in particular storage units such as FPSO, FSO, FSU...) carrying more than 20000 tons of crude oil in bulk in their tanks are to be fitted with an inert gas system complying with the provisions of this Article or with an equivalent fixed installation.

Note 1: To be considered equivalent, the system proposed in lieu of the fixed inert gas system is to:

- be capable of preventing dangerous accumulation of explosive mixtures in intact cargo tanks during normal service, loading and offloading and necessary in-tank operations, and
- be so designed as to minimize the risk of ignition from the generation of static electricity by the system itself.

b) All units operating with a cargo tank cleaning procedure using crude oil washing are to be fitted with an inert gas system complying with the requirements of this Article.

Such system is to be provided in every cargo tank and slop tank.

c) Units required to be provided with an inert gas system by item a) or b) above are to receive the additional class notation **IG**.

4.1.2 Units where an inert gas system is not required but provided with the additional class notation IG

Inert gas systems provided on units where such systems are not required by [4.1.1] and which are provided with the additional class notation IG are to comply with the provisions of [4.5.2].

4.2 General

4.2.1 The inert gas system referred to in [4.1] is to be designed, constructed and tested to the satisfaction of the Society.

4.2.2 Throughout this Article, the term "cargo tank" includes also slop tanks.

4.2.3 Detailed instruction manuals are to be provided on board, covering the operations, safety and maintenance requirements and occupational health hazards relevant to the inert gas system and its application to the cargo tank system. The manuals are to include guidance on procedures to be followed in the event of a fault or failure of the inert gas system.

Note 1: Refer to the Revised guidelines for inert gas systems adopted by the IMO Maritime Safety Committee at its forty-eight session in June 1983 (MSC/Circ. 353).

4.3 Principles

4.3.1 The inert gas system referred to in this Chapter is to be so designed and operated as to render and maintain the atmosphere of the cargo tanks non-flammable at all times, except when such tanks are required to be gas-free. In the event that the inert gas system is unable to meet the operational requirement set out above and it has been assessed that it is impractical to effect a repair, then cargo loading, offloading, and necessary tank cleaning are only to be resumed when the "emergency conditions" laid down in the Guidelines for Inert Gas Systems are complied with.

Note 1: Refer to the "Guidelines for Inert Gas Systems" approved by the IMO Maritime Safety Committee at its 42nd session, and subsequent amendments thereto, approved by the same Committee at its 48th and 50th sessions, which have been circulated through IMO Circulars MSC/Circ. 282, 353 and 387 respectively.

4.3.2 The system is to be capable of:

a) inerting empty cargo tanks by reducing the oxygen content of the atmosphere in each tank to a level at which combustion cannot be supported

b) maintaining the atmosphere in any part of any cargo tank with an oxygen content not exceeding 8 per cent by volume and at a positive pressure at all times in port and at sea except when it is necessary for such a tank to be gas-free

c) eliminating the need for air to enter a tank during normal operations except when it is necessary for such a tank to be gas-free

d) purging empty cargo tanks of hydrocarbon gas, so that subsequent gas-freeing operations will at no time create a flammable atmosphere within the tank.

4.3.3 The system is to be capable of delivering inert gas to the cargo tanks at a rate of at least 125 per cent of the maximum rate of discharge capacity of the unit expressed as a volume.

4.3.4 The system is to be capable of delivering inert gas with an oxygen content of not more than 5 per cent by volume in the inert gas supply main to the cargo tanks at any required rate of flow.

4.3.5 The inert gas supply may be treated flue gas from main or auxiliary boilers. The Society may accept systems using flue gases from one or more separate gas generators or other sources or any combination thereof, provided that an equivalent standard of safety is achieved. Such systems are, as far as practicable, to comply with the requirements of this Article. Systems using stored carbon dioxide are not permitted unless the Society is satisfied that the risk of ignition from generation of static electricity by the system itself is minimized.

4.3.6 The inert gas system is to be so designed that the maximum pressure which it can exert on any cargo tank will not exceed the test pressure of any cargo tank.

4.3.7 Arrangements are to be provided to enable the functioning of the inert gas plant to be stabilized before commencing cargo offloading.

4.3.8 An automatic control capable of producing suitable inert gas under all service conditions is to be fitted.

4.4 Design and arrangement of the system

4.4.1 Materials

Those parts of scrubbers, blowers, non-return devices, scrubber effluent and other drain pipes which may be subjected to corrosive action of the gases and/or liquids are to be either constructed of corrosion resistant material or lined with rubber, glass fibre epoxy resin or other equivalent coating material.

4.4.2 Inert gas supply

a) Two fuel oil pumps are to be fitted to the inert gas generator. The Society may permit only one fuel oil pump on condition that sufficient spares for the fuel oil pump and its prime mover are carried on board to enable any failure of the fuel oil pump and its prime mover to be rectified by the unit's crew.

b) Flue gas isolating valves are to be fitted in the inert gas supply mains between the boiler uptakes and the gas scrubber. These valves are to be provided with indicators to show whether they are open or shut, and precautions are to be taken to maintain them gas-tight and keep the seating clear of soot. Arrangements are be made to ensure that boiler soot blowers cannot be operated when the corresponding flue gas valve is open.

c) A gas regulating valve is to be fitted in the inert gas supply main. This valve is to be automatically controlled to close as required in items a) and b) of [4.4.11]. It is also to be capable of automatically regulating the flow of inert gas to the cargo tanks unless means are provided to automatically control the speed of the inert gas blowers required in [4.4.4].

   In case the gas generators are installed inside the hull in safe area, the valve referred to in the above paragraph is to be located at the forward bulkhead of the forward most or abaft bulkhead of the aftermost gas-safe space through which the inert gas supply main passes.

   In case the gas generators are installed on deck, the valves referred to in the above paragraph is to be located at an accessible area in the utilities area, close to the inert gas generator package.

Note 1: A gas-safe space is a space in which the entry of hydrocarbon gases would produce hazards with regard to flammability or toxicity.

4.4.3 Flue gas scrubber

a) A flue gas scrubber is to be fitted which will effectively cool the volume of gas specified in [4.3.3] and [4.3.4] and remove solids and sulphur combustion products.

b) The cooling water arrangements are to be that an adequate supply of water will always be available without interfering with any essential services of the unit. Provision is to be made for an alternative supply of cooling water.

c) Filters or equivalent devices are to be fitted to minimize the amount of water carried over to the inert gas blowers.

d) The scrubber is to be located outside of all cargo tanks, cargo pump-rooms and cargo aft and fore ends cofferdams separating these spaces from machinery spaces of category A.

4.4.4 Blowers

a) At least two blowers are to be fitted which together are to be capable of delivering to the cargo tanks the volume of gas required by [4.3.3] and [4.3.4]. In the system with gas generator, the Society may permit only one blower if that system is capable of delivering the total volume of gas required by [4.3.3] and [4.3.4] to the protected cargo tanks, provided that sufficient spares for the blower and its prime mover are carried on board to enable any failure of the blower and its prime mover to be rectified by the unit's crew.

Note 1: When two blowers are provided, the total required capacity of the inert gas system is preferably to be divided equally between them, and in no case is one blower to have a capacity less than 1/3 of the total capacity required.

b) Suitable shut-off arrangements are to be provided on the suction and discharge connections of each blower.

c) If the blowers are to be used for gas-freeing, their inlets are to be provided with blanking arrangements.

d) The blowers are to be located outside of all cargo tanks, cargo pump-rooms and cargo aft and fore ends cofferdams separating these spaces from machinery spaces of category A.

4.4.5 Means for preventing flue gas leakages

a) Special consideration is to be given to the design and location of scrubber and blowers with relevant piping and fittings in order to prevent flue gas leakages into enclosed spaces.

b) To permit safe maintenance, an additional water seal or other effective means of preventing flue gas leakage is to be fitted between the flue gas isolating valves and scrubber or incorporated in the gas entry to the scrubber.

4.4.6 Means for preventing the return of hydrocarbons

a) At least two non return devices, one of which is to be a water seal, are to be fitted in the inert gas supply main, in order to prevent the return of hydrocarbon vapour to the machinery space uptakes or to any gas-safe spaces under all normal conditions of trim, list and motion of the unit. They are to be located between the automatic valve required by item c) of [4.4.2] and the aftermost connection to any cargo tank or cargo pipeline.

b) The devices referred to in item a) above are to be located in the cargo area on deck.

c) The water seal referred to in item a) above is to be capable of being supplied by two separate pumps, each of which is to be capable of maintaining an adequate supply at all times.

d) The arrangement of the seal and its associated fittings is to be such that it will prevent backflow of hydrocarbon vapours and will ensure the proper functioning of the seal under operating conditions.

e) Provisions are to be made to ensure that the water seal is protected against freezing, in such a way that the integrity of seal is not impaired by overheating.

f) A water loop or other approved arrangement is also to be fitted to each associated water supply and drain pipe and each venting or pressure-sensing pipe leading to gas safe spaces. Means are to be provided to prevent such loops from being emptied by vacuum.

g) The deck water seal and all loop arrangements are to be capable of preventing return of hydrocarbon vapours at a pressure equal to the test pressure of the cargo tanks.

h) The second device is to be a non-return valve or equivalent capable of preventing the return of vapours or liquids and fitted forward of the deck water seal required in item a) above. It is to be provided with positive means of closure. As an alternative to positive means of closure, an additional valve having such means of closure may be provided forward of the non-return valve to isolate the deck water seal from the inert gas main to the cargo tanks.

i) As an additional safeguard against the possible leakage of hydrocarbon liquids or vapours back from the deck main, means are to be provided to permit this section of the line between the valve having positive means of closure referred to in item h) above and the valve referred to in item c) of [4.4.2] to be vented in a safe manner when the first of these valves is closed.

4.4.7 Inert gas piping system

a) The inert gas main may be divided into two or more branches forward of the non-return devices required by [4.4.6].

b) The inert gas supply main is to be fitted with branch piping leading to each cargo tank. Branch piping for inert gas is to be fitted with either stop valves or equivalent means of control for isolating each tank. Where stop valves are fitted, they are to be provided with locking arrangements, which are to be under the control of a responsible unit's officer. The control system operated is to provide positive indication of the operational status of such valves.

c) Piping systems are to be so designed as to prevent the accumulation of cargo or water in the pipelines under all normal conditions.

d) Suitable arrangements are to be provided to enable the inert gas main to be connected to an external supply of inert gas.

e) The inert gas supply main may be used for the venting of the vapours displaced from the cargo tanks during loading and offloading. See also Ch 1, Sec 10, [2].

f) If a connection is fitted between the inert gas supply mains and the cargo piping system, arrangements are to be made to ensure an effective isolation having regard to the large pressure difference which may exist between the systems. This is to consist of two shut-off valves with an arrangement to vent the space between the valves in a safe manner or an arrangement consisting of a spool-piece with associated blanks.

The valve separating the inert gas supply main from the cargo main and which is on the cargo main side is to be a non-return valve with a positive means of closure.

4.4.8 Connection of the adjacent spaces of the cargo and slop tanks to the inert gas distribution system

On units required to be fitted with inert gas systems:

a) the Society may require to provide suitable connections for the supply of inert gas into cofferdams, double hull and void spaces adjacent to cargo and slop tanks spaces

b) where hull spaces are connected to a permanently fitted inert gas distribution system, means are to be provided to prevent hydrocarbon gases from the cargo tanks entering to the cofferdams, double hull and void spaces adjacent to cargo and slop tanks through the inert gas system

c) where such spaces are not permanently connected to an inert gas distribution system, appropriate means are to be provided to allow connection to the inert gas main.

4.4.9 Instrumentation

a) Indication devices

Means are to be provided for continuously indicating the temperature and pressure of the inert gas at the discharge side of the gas blowers, whenever the gas blowers are operating.

b) Indicating and recording devices

1) Instrumentation are to be fitted for continuously indicating and permanently recording, when the inert gas is being supplied:
   - the pressure of the inert gas supply mains downstream of the non-return devices required by item a) of [4.4.6], and
   - the oxygen content of the inert gas in the inert gas supply mains on the discharge side of the gas blowers.
2) The devices referred to in item 1) above are to be placed in the cargo control room where provided. But where no cargo control room is provided, they are to be placed in a position easily accessible to the officer in charge of cargo operations.
3) In addition, meters are to be fitted:
   - in the central control room to indicate at all times the pressure referred to in the first item of bullet list of 1) above and the pressure in the slop tanks of combination units, whenever those tanks are isolated from the inert gas supply main, and
   - in the machinery control room or in the machinery space where the inert gas generator is fitted to indicate the oxygen content referred to in the second paragraph of item 1) above.

c) Portable instruments

Portable instruments for measuring oxygen and flammable vapour concentration are to be provided. In addition, suitable arrangement are to be made on each cargo tank such that the condition of the tank atmosphere can be determined using these portable instruments.

d) Means for instrument calibration

Suitable means are to be provided for the zero and span calibration of both fixed and portable gas concentration measurement instruments, referred to in b) and c) above.

e) Measuring instruments are summarized in Tab 2.

Table 2 : Measuring instruments, alarms and safety devices for inert gas systems

Parameters to be monitored	Alarms	Actions / Remarks
Water pressure / flow rate to gas scrubber	Low	Close regulating valve + Shut-off blowers + Shut-off fuel supply **(1)** **(2)**
Water level in gas scrubber	High	Close regulating valve + Shut-off blowers
I.G. temperature at gas blowers discharge side	High	Close regulating valve + Shut-off blowers + Shut-off fuel supply **(1)** **(2)**
Blowers	Failure	Close regulating valve
I.G. pressure at gas blowers discharge side	Low (10 mbar) + High	Continuous display
I.G. pressure downstream ton non-return valves **(3)**		Continuous display and permanent recording **(5)** + Shut-off cargo pump
I.G. oxygen content **(4)**	High (8%)	Continuous display and permanent recording **(5)**
Power supply to indicating devices **(5)**	Failure	
Power supply to regulating valve **(5)**	Failure	
Water level in deck water seal **(6)**	Low	
Fuel supply **(1)**	Failure	Close regulating valve **(2)**
Power supply **(1)**	Failure	Close regulating valve **(2)**
Power supply to automatic burning control system **(1)**	Failure	Close regulating valve **(2)**

(1) applicable to separate inert gas generators only.
(2) It is to be noticed that the provisions of Chapter 15 of IMO International Code for Fire Safety Systems do not require such parameters to be monitored or actions triggered off by alarms; these ones are therefore additional requirements.
(3) Continuous measurement device and permanent recorder are to be located in cargo storage control station with readings displayed in wheelhouse.
When cargo pump shut-off is not provided, an additional I.G. low pressure alarm system, independent from the first system, is to be provided.
Low pressure alarm system is to be provided in machinery, or at I.G. generator control station and at cargo storage control station.
(4) Alarm is to be provided in machinery, or at I.G. generator control station and at cargo storage control station.
Continuous measurement device and permanent recorder are to be located in cargo storage control station with readings displayed at machinery control station or in machinery.
(5) Alarm is to be provided in machinery, or at I.G. generator control station and at cargo storage control station.
The present requirement is applicable also to the alarm to be provided for failure of pressure permanent recorders.
(6) Alarm is to be triggered off when I.G. system is stopped.

4.4.10 Alarms

a) For inert gas systems of both the flue gas type and the inert gas generator type, audible and visual alarms are to be provided to indicate:

1) low water pressure or low water flow rate to the flue gas scrubber as referred to in [4.4.3]
2) high water level in the flue gas scrubber as referred to in [4.4.3]
3) high gas temperature as referred to in item a) of [4.4.9]
4) failure of the inert gas blowers referred to in [4.4.4]
5) oxygen content in excess of 8 per cent by volume as referred to in item b)1) of [4.4.9]
6) failure of the power supply to the automatic control system for the gas regulating valve and to the indicating devices as referred to in item c) of [4.4.2] and item b)1) of [4.4.9]
7) low water level in the water seal as referred to in item a) of [4.4.6]
8) gas pressure less than 100 mm water gauge as referred to in item b)1) of [4.4.9], and
9) high gas pressure as referred to in item b)1) of [4.4.9].

b) For inert gas systems of the inert gas generator type, additional audible and visual alarms are to be provided to indicate:

1) insufficient fuel oil supply
2) failure of the power supply to the generator
3) failure of the power supply to the automatic control systems for the generator.

c) The alarms required in items a)5), a)6) and a)8) above are to be fitted in the machinery space where the inert gas generator is located and in cargo control room, where provided, but in each case in such a position that they are immediately received by responsible members of the crew.

d) In respect of item a)7) above, the Society is to be satisfied as to the maintenance of an adequate reserve of water at all times and the integrity of the arrangements to permit the automatic formation of the water seal when the gas flow ceases. The audible and visual alarm on the low level of water in the water seal is to operate when the inert gas is not being supplied.

e) An audible alarm system independent of that required in item a)8) above or automatic shutdown of cargo pumps is to be provided to operate on predetermined limits of low pressure in the inert gas mains being reached.

f) Alarms are summarized in Tab 2.

4.4.11 Safeguards

a) Automatic shutdown of the inert gas blowers and gas regulating valve is to be arranged on predetermined limits being reached in respect of items a)1), a)2) and a)3) of [4.4.10].

b) Automatic shutdown of the gas regulating valve is to be arranged in respect of:

   1) a failure of the inert gas blowers referred to in [4.4.4]

   2) the power supply to the oil fired inert gas generators.

c) In respect of item a)5) above, when the oxygen content of the inert gas exceeds 8% by volume, immediate action is to be taken to improves the gas quality. Unless the quality of the gas improves, all cargo tank operations are to be suspended so as to avoid air being drawn into the tanks and the isolation valve referred to in item h) of [4.4.6] is to be closed.

d) Arrangements are to be made to vent the inert gas from oil fired inert gas generators to the atmosphere when the inert gas produced is off-specification, e.g. during starting-up or in the event of equipment failure.

e) Automatic shut-down of the oil fuel supply to inert gas generators is to be arranged on predetermined limits being reached with respect to low water pressure or mow water flow rate to the cooling and scrubbing arrangement and with respect to high gas temperature.

f) Safety devices are summarized in Tab 2.

4.5 Additional requirements

4.5.1 Nitrogen generator systems

a) The following requirements are specific only to the gas generator system and apply where inert gas is produced by separating air into its component gases by passing compressed air through a bundle of hollow fibres, semi-permeable membranes or absorber materials.

b) Where such systems are provided in place of the boiler flue gas or oil fired inert gas generators, the previous requirements for inert gas systems applicable to piping arrangements, alarms and instrumentation downstream of the generator are to be complied with, as far as applicable.

c) A nitrogen generator consists of a feed air treatment system and any number of membrane or absorber modules in parallel necessary to meet the required capacity which is to be at least 125% of the maximum discharge capacity of the unit expressed as a volume.

d) The air compressor and the nitrogen generator may be installed:

   - in hull: in the engine room or in a separate compartment. A separate compartment is to be treated as one of the "Other machinery spaces" category (7) with respect to fire protection, or
   - in the topside modules: at a suitable location outside hazardous areas as defined in Pt C, Ch 4, Sec 3.

e) In connection with above, where a separate compartment is provided, it is to be positioned outside the cargo area and is to be fitted with an independent mechanical extraction ventilation system providing 6 air changes per hour. A low oxygen alarm is to be fitted as well. The compartment is to have no direct access to accommodation spaces, service spaces and control stations.

f) The nitrogen generator is to be capable of delivering high purity nitrogen with O2 content not exceeding 5% by volume. The system is to be fitted with automatic means to discharge off-specification gas to the atmosphere during start-up and abnormal operation.

g) The system is to be provided with two air compressors. The total required capacity of the system is preferably to be divided equally between the two compressors, and in no case is one compressor to have a capacity less than 1/3 of the total capacity required. Only one air compressor may be accepted provided that sufficient spares for the air compressor and its prime mover are carried on board to enable their failure to be rectified by the unit's crew.

h) A feed air treatment system is to be fitted to remove free water, particles and traces of oil from the compressed air, and to preserve the specification temperature.

i) Where fitted, a nitrogen receiver/buffer tank may be installed depending on the location of the generator:

   - in hull: in a dedicated compartment or in the separate compartment containing the air compressor and the generator or may be located in the cargo area. Where the nitrogen receiver/buffer tank is installed in an enclosed space, the access is to be arranged only from the open deck and the access door is to open outwards. Permanent ventilation and alarm are to be fitted as required by item e) above
   - in the topsides: close to the generators or in the cargo area.

j) The oxygen-enriched air from the nitrogen generator and the nitrogen-product enriched gas from the protective devices of the nitrogen receiver are to be discharged to a safe location on the open deck.

k) In order to permit maintenance, means of isolation are to be fitted between the generator and the receiver.

l) At least two non-return devices are to be fitted in the inert gas supply main, one of which is to be of the double block and bleed arrangement. The second non-return device is to be equipped with positive means of closure.

Note 1: A block and bleed arrangement consisting of two shut-off valves in series with a venting valve in between may be accepted provided:

- the operation of the valve is automatically executed. Signal(s) for opening/closing is (are) to be taken from the process directly, e.g. inert gas flow or differential pressure
- alarm for faulty operation of the valves is provided, e.g. the operation status of "blower stop" and "supply valve(s) open" is an alarm condition.

m) Instrumentation is to be provided for continuously indicating the temperature and pressure of air:

1) at the discharge side of the compressor

2) at the entrance side of the nitrogen generator.

n) Instrumentation is to be fitted for continuously indicating and permanently recording the oxygen content of the inert gas downstream of the nitrogen generator when inert gas is being supplied.

o) The instrumentation referred to in the preceding item n) is to be placed in the cargo control room.

p) Audible and visual alarms are to be provided to indicate:

1) low feed-air pressure from compressor as referred to in item m)1) above

2) high air temperature as referred to in m)1) above

3) high condensate level at automatic drain of water separator as referred to in item h) above

4) failure of electrical heater, if fitted

5) oxygen content in excess of that required in f) above

6) failure of power supply to the instrumentation as referred to in item n) above.

q) Automatic shutdown of the system is to be arranged upon alarm conditions as required by p)1) to p)5) above.

r) The alarms required by items p)1) to p)6) above are to be fitted in the machinery space and cargo control room, where provided, but in each case in such a position that they are immediately received by responsible members of the crew.

4.5.2 Nitrogen/inert gas systems fitted on units (in particular storage units as FPSO, FSO, FSU...) carrying less than 20000 tons of crude oil and for which an inert gas system is not required by [4.1.1] are to comply with the following:

a) The provisions of [4.5.1] apply except items a) to c) and item g).

b) Where the connections to the cargo tanks, to the hold spaces or to cargo piping are not permanent, the non-return devices required by item l) of [4.5.1] may be replaced by two non-return valves.

5 Hydrocarbon blanket gas system

5.1 General

5.1.1 Application

In addition to the inert gas system required in the present Section, an hydrocarbon blanket gas system may be installed. It will help to reduce Volatile Organic Compound (VOC) releases to atmosphere.

If a hydrocarbon blanket gas system is installed, a cargo tank vents recovery system referred to in Ch 1, Sec 10, [3] shall also be fitted.

5.1.2 Principles

The principle of the hydrocarbon blanket gas system is to replace the use of inert gas with pure hydrocarbon (HC) blanket gas in the cargo tanks and to recover the off gas.

Gas from the process will be used as blanket gas during cargo tank offloading. During loading the gas emitted from the cargo tanks will be recovered and recycled in the process plant.

5.1.3 General prescriptions

a) The inert gas system required by the provision of [4.1.1] will remain as a backup system in case the hydrocarbon blanket gas sources are not available (e.g. production stopped), or if there is a need to gas free cargo tanks for purposes such as maintenance.

b) When using inert gas as blanket gas, the blanket gas recovery system is to be shutdown to prevent inert gas entering the re-compression train.

c) The hydrocarbon blanket gas system is to be designed, constructed and tested to the satisfaction of the Society.

d) Throughout the present [5], the term “cargo tanks” includes also slop tanks.

e) Detailed instruction manuals are to be provided on board, covering the operations (including first time start up, change-over from inert to hydrocarbon blanket gas and gas freeing), safety and maintenance requirements.

f) Piping, fittings and mechanical parts of this hydrocarbon blanket gas system are to comply with Part C, Chapter 1 and are to be designed for the hydrocarbon blanket gas maximum possible supply temperature and pressure.

g) Equipment must be suitable for the hazardous area where they are located.

h) This hydrocarbon blanket gas system is to remain within the cargo area.

i) The limit of the scope of Classification (without **PROC** notation) is generally:

- upstream at the gas regulating valve referred to in [5.6.1]
- downstream as defined in Ch 1, Sec 10, [3.1.10].

j) Depending on the findings of the HAZOP studies, the Society may raise additional requirements.

5.1.4 Documents to be submitted

The following documents are to be submitted for review:

- process and instrumentation diagrams of the hydrocarbon blanket gas system and of its connection to the cargo tanks system, to the inert gas system, to the venting systems and to the cargo tank vents recovery system referred to in Ch 1, Sec 10, [3]
- cause & effect diagram for the system
- settings of the pressure / vacuum protection devices
- HAZID and HAZOP studies of the system
- explosion hazard study which investigates hydrocarbon leaks from tank hatches or hydrocarbon blanket gas pipes.

5.2 Materials

5.2.1 Coating of the cargo tanks shall be suitable for the hydrocarbon blanket gas composition.

5.3 Piping system

5.3.1 Piping systems are to be so designed as to prevent the accumulation of hydrocarbon blanket gas in the pipelines under all normal conditions.

5.3.2 Arrangements are to be made to limit the carriage of water present in hydrocarbon blanket gas in the cargo tanks.

5.3.3 Arrangements are to be made to ensure an effective isolation of the cargo tanks and the hydrocarbon blanket gas supply source. This may consist in a fast closing shutdown valve.

5.4 Capacity of the system

5.4.1 The hydrocarbon blanket gas supply capacity shall be at least 125% of maximum offloading rate at cargo tank conditions.

5.5 Venting arrangement and pressure/vacuum protection

5.5.1 As a general rule, the venting and pressure/vacuum protection systems are to be so designed that the minimum and maximum pressures exerted on any cargo tank considering the process systems will not exceed the test pressures of any cargo tank.

5.5.2 As a general rule, the arrangement of the venting and pressure/vacuum protection systems shall ensure that no flammable mixtures will be present in the cargo tanks.

5.5.3 Relief capacity of the venting arrangements required in Ch 1, Sec 10, [2.2] shall be designed considering the possible maximum hydrocarbon blanket gas supply if one tank is loaded with all gas connections isolated.

5.5.4 The vacuum protection system is to be designed considering a flow rate equal to the maximum offloading rate from the cargo tanks.

5.5.5 Settings of the pressure/vacuum protection system shall take into account the hydrocarbon blanket gas supply and recovery and shall remain within the range defined in Ch 1, Sec 10, [2.1.7].

5.5.6 Cargo vents, if discharged to the atmosphere, shall be led to well-ventilated safe areas.

5.6 Instrumentation

5.6.1 A gas regulating valve is to be fitted in the hydrocarbon blanket gas supply line upstream the shutdown valve mentioned in [5.3.3].

5.6.2 In addition to instrumentation devices and alarms required in Ch 1, Sec 10, [3.6.2] the following are to be provided for continuously recording and indicating:

a) Pressure in each individual cargo tank protected by the hydrocarbon blanket gas system. The pressure loss from the cargo tank to this transmitter is to be as low as possible.

b) Temperature of the hydrocarbon blanket supply gas upstream the gas regulating valve mentioned in [5.6.1].

c) the oxygen content in each individual cargo tank protected by the hydrocarbon blanket gas system.

5.6.3 The alarms referred to in [5.6.2] are to be fitted in the machinery space and cargo control room, where provided, but in each case in such a position that they are immediately received by responsible members of the crew.

5.7 Safeguards

5.7.1 In addition to safeguards required in Ch 1, Sec 10, [3.7] the following are to be provided:

a) Automatic shutdown of the shutdown valve mentioned in [5.3.3] and of the hydrocarbon blanket gas system is to be arranged on predetermined limits being reached in respect of [5.6.2], item a) (High).

b) Automatic shutdown of the cargo offloading or transfer pumps is to be arranged on predetermined limits being reached in respect of [5.6.2], item a) (Low).

c) Automatic shutdown of the cargo offloading or transfer pumps is to be arranged in respect of [5.6.2] item c) above, when the oxygen content exceeds 5% by volume.

d) Automatic shutdown of the hydrocarbon blanket gas supply is to be arranged in respect of Ch 1, Sec 10, [3.6.2] item e) (failure of the recovery equipment)].

Note 1: The requirements of [5.7.1] may be adapted based on the findings and conclusions of the HAZOP report.

5.8 Miscellaneous

5.8.1 An adequate automatic gas detection system complying with Pt C, Ch 4, Sec 5, [4] is to be fitted on the main cargo deck.

5.8.2 Any tank that is prepared for maintenance/inspection activities is to be kept isolated from all the other tanks, hydrocarbon blanket.

5.8.3 Depending on findings of the HAZOP studies, the Society may raise additional requirements.

6 Cargo and slop tanks fittings

6.1 Application

6.1.1 Requirements of the present [6] are complementary to relevant requirements of Part C, Chapter 1 which remain applicable.

6.2 Protection of cargo and slop tanks against overfilling

6.2.1 General

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.

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 [6.3].

6.2.2 High level alarms

a) High level alarms are to be type approved.

b) High level alarms are to give an audible and visual signal at the central control room, where provided.

6.2.3 Other protection systems

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 [6.2.1] 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 [6.3]. 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 [6.2.1] are considered as complied with.

6.3 Cargo and slop tanks level gauging systems

6.3.1 General

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.

6.3.2 Definitions

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:

   1) penetrate the tank, such as float-type systems, electric probe, magnetic probe or protected sight glass

   2) 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.

6.3.3 Units fitted with an inert gas system

a) In units 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.

6.3.4 Units not fitted with an inert gas system

a) In units 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:

   1) avoid dangerous escape of liquid or vapour under pressure when using the device

   2) relieve the pressure in the tank before the device is operated.

c) Where used, sounding pipes are to be fitted with a self-closing blanking device.

6.4 Heating systems intended for cargo and slop tanks

6.4.1 General

a) Heating systems intended for cargo are to comply with the relevant requirements of Part C, Chapter 1.

b) No part of the heating system is normally 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 adjustment of the flow.

f) Heating pipes and coils inside tanks are to be built of a material suitable for the heated fluid and of reinforced thickness as per Pt C, Ch 1, Sec 7. They are to have welded connections only.

6.4.2 Steam heating

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:

a) they are to be independent of other unit services, except cargo heating or cooling systems, and are not to enter machinery spaces, or

b) 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.

6.4.3 Hot water heating

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:

a) means for detection of flammable vapours

b) a vent pipe led to the open and provided with a flame arrester.

6.4.4 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:

a) the system is so arranged as to ensure a positive pressure in the coil of at least 3 meter water column above the static head of the cargo when the circulating pump is not in operation

b) means are provided in the expansion tank for detection of flammable cargo vapours. Portable equipment may be accepted

c) valves for the individual heating coils are provided with a locking arrangement to ensure that the coils are under static pressure at all times.

6.5 Cleaning of cargo and slop tanks

6.5.1 Adequate means are to be provided for cleaning the cargo tanks.

6.5.2 Units having a storage capacity of 20 000 tons of crude oil and above is to be fitted with a cargo tanks cleaning system using crude oil washing complying with the following requirements. Unless the cargo stored in such unit is not suitable for crude oil washing, the unit is to operate the system with the following requirements.

Note 1: The crude oil washing installation and associated equipment and arrangements are to comply with the requirements of MARPOL 73/78 Annex I convention and IMO Resolution A.446(XI) as amended by Resolutions A.497(XII) and A.897(21).

6.5.3 Every offshore unit operating with crude oil washing system is to be provided with an Operations and Equipment Manual detailing the system and equipment and specifying operational procedures such a manual is to be to the satisfaction of the Society and is to contain all the information set out Note 1 of [6.5.2]. If an alteration affecting the crude oil washing system is made, the Operating and Equipment Manual is to be revised accordingly.

Note 1: For the Standard format of the Crude Oil Washing Operation and Equipment Manual reference is made to the IMO Resolution MEPC.3(XII) as amended by IMO Resolution MEPC.81(43).

6.5.4 Fixed or portable tank washing machines are to be of a type approved by the Society.

Note 1: Washing machines are to be made of steel or other electricity conducting materials with a limited propensity to produce sparks on contact.

6.5.5 Fixed washing machines are to be installed and secured to the satisfaction of the Society. They are to be isolated by a valve or equivalent device.

6.5.6 Washing pipes are to be built, fitted, inspected and tested in accordance with the requirements of Part C, Chapter 1 and of other documents referred to in this Chapter applicable to pressure piping, depending of the kind of washing fluid, water or crude oil.

6.5.7 Washing machines of floating storage units using a crude oil washing system are to be fixed.

6.5.8 Crude oil washing pipes are to satisfy the requirements of [3] applicable to cargo pipes. However, 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.

6.5.9 Crude oil washing pipes, if used for water washing operations, are to be fitted with efficient drainage means.

6.5.10 If crude oil and water washing pipes are not separated, the washing water heater is to be placed outside the engine room and is to be isolated by valves or other equivalent clearly marked arrangements.

6.5.11 The installation of the washing systems is to comply with the following provisions:

a) Tank cleaning openings are not to be arranged in enclosed spaces.

b) The complete installation is permanently earthed to the hull.

6.6 Gas detectors

6.6.1 The following are to be provided:

- at least two portable flammable gas monitoring devices, each capable of accurately measuring a concentration of flammable gas
- at least one portable oxygen content meter.

These devices are to be of a type approved by the Society.

6.6.2 A fixed automatic gas detection and alarm system is to be provided to the satisfaction of the Society so arranged as to monitor continuously all enclosed areas of the unit in which an accumulation of flammable gas may be expected to occur, and capable of indicating at the main control point by audible and visual means the presence and location of an accumulation.

The same system is to be provided at ventilation inlets to safe areas.

6.7 Cathodic protection

6.7.1 Unless specially authorised by the Society, impressed current cathodic protection systems are not to be used in cargo oil or slop tanks.

6.7.2 Aluminium or magnesium alloy anodes are not to be used in cargo and slop tanks.

6.7.3 Aluminium anodes are permitted in cargo and slop tanks only if their potential energy does not exceed 0,275 kJ, the height of the anode being measured from the tank bottom to the centre of the anode and its weight being the total weight, including the securing devices.

Where an aluminium anode is fitted above an horizontal surface such as a bulkhead stiffener, and provided that the stiffener measures at least 1 m in width and comprises a flange extending at least 75 mm above its horizontal surface, the anode height may be measured to the horizontal surface of the stiffener.

Aluminium anodes are not to be located under access hatches or washing holes unless they are protected by the adjacent structure.

6.7.4 In all cases, the anodes are to be properly secured to the structure.

6.7.5 As a general rule, the requirements of the present [6.7] are applicable also to compartments adjacent to cargo or slop tanks.

6.8 Aluminium paints

6.8.1 Aluminium paints are not to be used in cargo and slop tanks, pump rooms, cofferdams, or wherever dangerous vapours may gather unless it is justified by tests that the paints utilised do not increase the risk of spark production.

7 Bow or stern cargo oil transfer

7.1 General

7.1.1 Bow or stern cargo transfer installations are to comply with the applicable requirements of [3] and [7.2]. Portable arrangements are not permitted.

7.2 Piping requirements

7.2.1 Cargo piping outside the storage area is to be clearly identified and fitted with shut-off valves at connections to the cargo piping system within the storage area and, where applicable, at junctions with flexible hose(s) or articulated piping used for connection with single point mooring or riser.

Note 1: 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 are to be provided when the piping is not in use, irrespective of the number and type of valves in the line.

7.2.2 Article [3] is applicable. Moreover, pipe connections outside the storage area are to be of welded type only.

7.2.3 Arrangements are to be made to allow piping to be efficiently drained and purged.

7.3 Openings

7.3.1 Openings are to comply with Ch 1, Sec 11, [6.2.5].

7.4 Coamings

7.4.1 Continuous coamings of suitable height are to be fitted to keep spills on deck and away from the accommodation and service areas.

Escape routes are not to terminate within the limits of these coamings or within a distance of 3 m from them.

The zones within the limits and a distance of 3 m beyond these coamings are considered as hazardous zones 1 or 2, according to Ch 1, Sec 11, [2.2].

7.5 Fire fighting

7.5.1 Where the loading and offloading areas of the unit are not protected by the fixed deck foam system required in Ch 1, Sec 11, [6.5], 2 additional foam monitors or applicators are to be provided to protect these areas.

7.6 Fire-fighting system

7.6.1 The fixed foam fire-fighting system provided for the application of Ch 1, Sec 11, [6.5] is to permit the protection of the transfer zone by at least two foam applicators.

7.7 Remote shut-down

7.7.1 Provision is to be made for the remote shut-down of cargo pumps from the cargo transfer location.

Means of communication between the loading control station and the cargo transfer location are to be provided and certified safe, if necessary.

SECTION 13 USE OF PROCESS GAS AND CRUDE OIL AS FUEL

1 General

1.1 Application

1.1.1 This Section addresses the design of machinery fuelled with process gas or crude oil, as well as the arrangement of the spaces where such machinery is located.

1.2 Additional requirements

1.2.1 Additional requirements for machinery are given in:

- Rule Note NR 481, Design and Installation of Dual Fuel Engines Using Low Pressure Gas
- Pt C, Ch 1, App 1, which addresses the design of dual fuel diesel engines using high pressure gas.

1.3 Documents to be submitted

1.3.1 The drawings and documents to be submitted for gas fuelled installations are listed in Rule Note NR 481 "Design and installation of dual fuel engines using low pressure gas".

1.3.2 The drawings and documents to be submitted for crude oil fuelled installations are to include at least:

- general arrangement of the engine or boiler compartment
- general arrangement of the auxiliary compartment
- diagram and PID for crude oil and fuel oil (HFO/MDO) systems inside auxiliary compartment and engine or boiler compartment
- ventilation diagram and location of the crude oil vapour detectors
- details of the pipe ducting system (on the engine or boiler and external) and hoods, where provided
- details of the leakage detection system
- specification of the engines or boilers, auxiliary systems, electrical equipment, etc.
- risk analysis covering the operation of the engines on crude oil as well as the possible presence of crude oil vapours in the machinery spaces.

1.4 Definitions

1.4.1 Low pressure / high pressure gas

Low pressure gas means gas with a maximum service pressure less than or equal to 50 bar gauge.

1.4.2 Engine

"Engine" means either a diesel engine or a gas turbine.

1.4.3 Dual fuel engine (or boiler)

A dual fuel engine (or boiler) is an engine (or boiler) which can be operated with liquid fuel (MDO or HFO) and gaseous fuel.

1.4.4 Crude oil engine (or boiler)

A crude oil engine (or boiler) is an engine (or boiler) which can be operated either with liquid fuel (MDO or HFO) or with crude oil, successively.

2 Requirements applicable to process gas and to crude oil

2.1 Principle

2.1.1 Engines (or boilers) intended to burn process gas or crude oil are also to be capable of burning bunker fuel oils (MDO or HFO) in case of failure of the process gas or crude oil supply.

2.1.2 The arrangement of the machinery spaces containing dual fuel or crude oil engines or boilers, the distribution of the engines or boilers and the design of the safety systems are to be such that, in case of any gas or crude oil vapours leakage, the automatic safety actions will not result in all engines or boilers being disabled. Provisions are to be made to maintain the essential services of the unit in such case.

2.1.3 The use of gases heavier than air is not permitted in machinery spaces, except if it is demonstrated that the geometry of the space bottom and the arrangement of the ventilation system preclude any risk of gas accumulation.

2.2 Ventilation

2.2.1 Spaces in which gas fuel or crude oil is utilized are to be fitted with a mechanical ventilation system and are to be arranged in such a way as to prevent the formation of dead spaces. Such ventilation is to be particularly effective in the vicinity of electrical equipment and machinery or of other equipment or machinery which may generate sparks. Such a ventilation system is to be separated from those intended for other spaces.

2.3 Gas detection

2.3.1 Gas detectors are to be fitted in all machinery spaces where gas or crude oil is utilized, particularly in the zones where air circulation is reduced. The gas detection system is to comply with the requirement of Pt C, Ch 4, Sec 5, [5.2].

2.3.2 Gas detectors are also to be provided where required in Articles [3] and [4], i.e. in ducts containing gas or crude oil pipes, hoods, etc.

2.4 Electrical equipment

2.4.1 Electrical equipment installed in gas dangerous areas or in areas which may become dangerous (such as hoods, ducts or covers in which gas or crude-oil piping is placed) is to be of certified safe type as required by Pt C, Ch 2, Sec 15.

3 Use of process gas

3.1 Gas conditioning and storage conditions

3.1.1 General

The installations required for conditioning the gas for use in boilers or engines (heating, compression, etc.) and possible storage are to be situated on the weather deck in the storage area, due precautions being taken for the protection of these installations against the sea and for their free access under normal circumstances. If those installations are situated in closed rooms on the weather deck, such rooms are to be efficiently exhaust ventilated by means of a mechanical ventilating system completely independent from the other ventilation systems of the unit and fitted with gas detectors. These rooms are to communicate with the outside only.

The scantlings and construction of the various pressure parts of the installation are to comply with the applicable requirements of the present chapter and of Pt C, Ch 1, Sec 3 (pressure equipment) and Pt C, Ch 1, Sec 7 (piping systems).

3.1.2 Heaters - Coolers

Operation of the heaters/coolers is to be automatically regulated according to the temperature of the gas at the outlets.

Before their possible return to the machinery compartments, the heating/cooling fluids are, normally, to pass through a gas freeing tank fitted with a pipe provided with a gas detector and exhausting to the open air.

3.1.3 Compressors

Discharge of the compressors is to be automatically stopped:

- when the suction pressure falls below the atmospheric pressure or a pressure determined as a function of the setting of the crude oil tank vacuum safety valves
- when the discharge pressure or the pressure in the crude oil tanks reaches a value determined as a function of the setting of the safety valves fitted on the high pressure side of the compressors or on the crude oil storage tanks
- in case of lowering of the temperature of the gas at the heater outlets.

The compressors are to be capable of being remotely stopped from a place easily accessible at all times as well as from the machinery compartment.

3.1.4 Reducing valves

The reducing valves provided on the gas system are to be installed as specified in [3.1.1].

The reducing valves are to be fitted on the low pressure side, with safety outlets discharging in the open air.

3.1.5 Protection against overpressure

The usual overpressure safety devices are to be fitted. This is applicable, in particular, to safety valves on the compressors, crude oil storage tanks and, possibly, heaters, all such safety valves discharging in the open air.

3.2 Gas fuel supply to engines and boilers

3.2.1 General

Gas fuel piping for engine and boiler supply is not to pass through accommodation spaces, services spaces, or control stations. Gas fuel piping may pass through or extend into other spaces provided its design fulfils the provisions of Tab 1.

If a gas leak occurs, the gas fuel supply should not be restored until the leak has been found and repaired. Instructions to this effect should be placed in a prominent position in the machinery spaces.

Table 1 : Design principle of the gas fuel piping

Working pressure (bar)	Nature of the gas	
	Lighter than air	Heavier than air
≤10	• double-walled piping according to [3.2.2] or • safeguarded machinery spaces according to [3.2.3] **(1)**	double-walled piping according to [3.2.2]
>10	double-walled piping according to [3.2.2]	

(1) "Safeguarded machinery spaces" arrangement is subject to the agreement of the Flag Administration.

3.2.2 Double-walled piping arrangement

a) *Double-walled piping systems are to fulfil one of the following:*

   1) *the gas fuel piping should be of a double-wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes should be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms should be provided to indicate the loss of inert gas pressure between the pipes.* The pressure in the space between the concentric pipes is to be continuously monitored. An alarm is to be issued and the two automatic valves on the gas fuel line and the master gas valve referred to in [3.2.7] are to be closed before the pressure drops to below the inner pipe pressure. At the same time, the interlocked venting valve is to be opened. The inside of the gas fuel supply piping system between the master gas valve and the engine is to be automatically purged with inert gas when the master gas valve is closed*; or*

   2) *the gas fuel piping should be installed within a ventilated pipe or duct. The air space between the gas fuel piping and inner wall of this pipe or duct should be equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes par hour. The ventilation system should be arranged to main-*

tain a pressure less than the atmospheric pressure. The fan motors should be placed outside the ventilated pipe or duct. The ventilation outlet should be placed in a position where no flammable gas-air mixture may be ignited. The ventilation should always be in operation when there is gas fuel in the piping. Continuous gas detection should be provided to indicate leaks. It should activate the alarm at 30% of the lower flammable limit and shut down the gas the master gas fuel valve referred to in [3.2.7] before the gas concentration reaches 60% of the lower flammable limit. The master gas fuel valve should close automatically if the required air flow is not established and maintained by the exhaust ventilation system.

The air intakes of the mechanical ventilation system are to be provided with non-return devices effective for gas fuel leaks. However, if a gas detector is fitted at the air intake, this requirement may be dispensed with.

The materials, construction and strength of protection pipes or ducts and mechanical ventilation systems are to be sufficiently durable against bursting and rapid expansion of high pressure gas in the event of gas pipe burst.

b) *The double-wall piping system of the ventilated pipe or duct provided for the gas fuel piping should terminate at the ventilation hood or casing required by [3.2.9].*

3.2.3 Arrangement of the “safeguarded machinery spaces”

Where permitted, safeguarded machinery spaces arranged in accordance with the following provisions may be accepted as an alternative to [3.2.2]:

a) Volume of the machinery spaces

The volume of the machinery spaces is to be kept as low as practicable, to facilitate the ventilation and gas detection.

b) Piping arrangement

Pipes are to be installed as far as practicable from hot surfaces and electrical equipment.

c) Ventilation

The machinery spaces are to be fitted with a ventilation system of the extraction type complying with the following provisions:

- the ventilation system is to maintain a pressure less than that of the adjacent spaces, this pressure being permanently monitored
- the capacity of the ventilation system is to be at least 30 changes per hour
- the ventilation system is to be so arranged as to ensure an immediate and effective evacuation of the leaked gas, whatever the location and the extent of the piping damage. In particular, the possibility of gas accumulation in dead spaces is to be precluded
- the exhaust fans are to be of a non-sparking type
- the prime movers of the exhaust fans are to be located outside the concerned space and outside the exhaust ducts serving the compartment. Alternatively, intrinsically safe motors may be used
- the exhaust duct is to be led to a location where there is no risk of ignition.

d) Electrical equipment

The electrical equipment not pertaining to the engine and which is required for the safety of the compartment (such as lighting or ventilation) is to be of a safe type.

In case of gas detection with a concentration reaching 60 percent of the LFL, the other electrical equipment situated in the compartment is to be de-energized by switching off their electrical supply.

e) Gas monitoring systems

At least one gas monitoring system is to be provided in way of each engine, and one in the compartment at the exhaust air outlet.

Gas monitoring systems are to of the continuous type. They are to be so designed as to avoid any false detection. Voting systems or equivalent arrangement are to be considered for this purpose.

f) Validation tests

The efficiency of the ventilation system and gas monitoring installation is to be demonstrated by means of appropriate analysis or tests for all operating cases (number of engines in operation, power developed by the engines, ventilation rate). In particular, the following parameters are to be validated:

- position of the ventilation inlets and outlets
- distribution of the ventilation flows
- number and distribution of the gas detectors.

3.2.4 Class of the gas piping

Class of the gas piping is to comply with the provisions of Tab 2.

Table 2 : Class of gas piping

Gas piping type	Class I	Class II	Class III
Double wall type with pressurized and inerted external pipe (see [3.2.2] item a)1))			
• internal pipe		X	
• external pipe		X	
Double wall type with inerted external pipe or duct (see [3.2.2] item a)2))			
• internal pipe		X	
• external pipe or duct			X
Gas pipe arranged according to the “safeguarded machinery space” (see [3.2.3])	X		
Open-ended gas vent lines			X

3.2.5 Materials

Materials used in gas supply lines are to comply with the relevant provisions of IGC Code, Chapters 5 and 6.

3.2.6 Pipe connections

a) Class I pipes

Class I pipes are to be connected by means of full penetration butt-welded joints. However, welded neck flanges (type A1 according to Pt C, Ch 1, Sec 7, Fig 1) restricted to the minimum necessary for mounting and dismantling purposes may be accepted. All welded joints are to be fully radiographied.

b) Class II pipes

Class II pipes may be connected as required in a) above or by means of slip-on or socked welded flanges. Other piping connections may be accepted by the Society on a case by case basis.

Note 1: Screwed couplings of a type approved by the Society may be used only for accessory lines and instrumentation lines with external diameters of 25 mm or less.

3.2.7 Automatic shut-off valves

a) Block-and-bleed valves

Each gas utilization unit should be provided with a set of three automatic valves. Two of these valves should be in series in the gas fuel pipe to the consuming equipment. The third valve should be in a pipe that vents, to a safe location in the open air, that portion of the gas fuel piping that is between the two valves in series. These valves should be arranged so that abnormal pressure in the gas fuel supply line, or failure of the valve control actuating medium will cause the two gas fuel valves which are in series to close automatically and the vent valve to open automatically. Alternatively, the function of one of the valves in series and the vent valve can be incorporated into one valve body so arranged that, when one of the above conditions occurs, flow to the gas utilization unit will be blocked and the vent opened. The three shutoff valves should be arranged for manual reset.

Note 1: Block-and-bleed valves are also to be fitted on the pilot burners supply lines.

b) Master gas valves

A master gas fuel valve that can be closed from within the machinery space should be provided within the cargo area. The valve should be arranged so as to close automatically if leakage of gas is detected, or loss of ventilation for the duct or casing or loss of pressurization of the double-wall gas fuel piping occurs.

3.2.8 Gas pressure regulation

When supplying engines, the gas fuel system is to be provided with a pressure regulation system allowing a gas supply to the engines at the required pressure without significant fluctuations, irrespective of the number of engines in operation and of the developed power. Where necessary a buffer tank is to be fitted.

3.2.9 Ventilation hoods and casings

A ventilation hood or casing should be provided for the areas occupied by flanges, valves, etc., and for the gas fuel piping, at the gas fuel utilization units, such as boilers, diesel engines or gas turbines. If this ventilation hood or casing is not served by the exhaust ventilation fan serving the ventilated pipe or duct as specified in [3.2.2] a) 2), then it should be equipped with an exhaust ventilation system and continuous gas detection should be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with [3.2.2] a) 2). The master gas fuel valve required by [3.2.7] b) should close automatically if the required air flow is not established and maintained by the exhaust ventilation system.

Note 1: When the machinery space is arranged according to the "safeguarded machinery spaces" principle (see [3.2.3]), the ventilation hood or casing is not required.

In the case of gas fuel lighter than air, *the ventilated hood or casing is to be installed or mounted to permit the ventilating air to sweep across the gas utilization unit and be exhausted at the top of the ventilation hood or casing.*

In the case of gas fuel heavier than air, the ventilated hood or casing is to be so arranged as to permit the ventilating air to sweep across the engine or turbine and be exhausted at the bottom of the ventilation hood or casing.

3.3 Dual fuel engines

3.3.1 Dual fuel engines are to be type-approved by the Society.

3.3.2 Dual fuel engines are to be designed so as to operate safely with any gas composition within the unit specification range, taking into account the possible variations of the gas composition during the process operations. Tests are to be conducted to demonstrate their ability in this respect.

3.3.3 The fuel supply is to be capable of being switched over from gas fuel to oil fuel while the engine is running at any load, without significant fluctuation of the engine output nor of the rotational speed.

3.3.4 Prior to a normal stop, the engine is to be switched over from gas fuel to oil fuel.

3.3.5 After each gas operation of the engine not followed by a oil fuel operation, the engine including the exhaust system is to be purged during a sufficient time in order to discharge the gas which may be present.

3.3.6 Engines are to be fitted with a control system allowing a steady running with stable combustion, with any kind of gas as mentioned above, throughout the operating speed range of the engine, in particular at low loads.

3.3.7 Engines are to be so designed and controlled as to avoid any excessive gas delivery to the engine, which may result in the engine overspeed, in particular while the engine is running with gas fuel and oil fuel at the same time.

3.3.8 Gas piping located on the engine is to comply with the provisions of [3.2].

3.4 Dual fuel boilers

3.4.1 Liquid fuel pilot burner

For dual-fuel boilers, a liquid fuel pilot burner is normally to be permanently in service on the boiler when the boiler is working and a safety device is to be fitted to prevent gas supply when this burner is not in service.

However, the gas supply to the boiler without the pilot burner in service may be admitted, subJect to the following arrangements:

- the gas burners are to be ignited by the liquid fuel burners
- the eventual switching to the liquid fuel is to be automatic and as fast as possible in order to shorten the duration of the power loss, taking into account the possible durations for scavenging and pressure recovery
- for this purpose, the liquid fuel burners and their supply piping are always to be kept available during stand-by while gas firing
- the flame detection is to be efficient for all firing conditions
- in the event of a complete loss of flame in the furnace, the ignition procedure of the liquid fuel burners must include an efficient scavenging of the furnace.

3.4.2 Safety devices

Safety devices are to be provided for the automatic stopping of the gas supply to the boiler in the following cases:

- abnormal variation in the pressure of the gas
- abnormal variation in the pressure of the air
- stopping of the forced draught fans
- extinction of the gas burners.

Each burner is to be fitted with a quick closing cock or valve, so designed that the burner cannot possibly be withdrawn without the gas supply being automatically cut off.

Precautions are to be taken to ensure the stability of the flame of the gas burners, specially at low load. A device is to be provided to maintain the ratio air-gas at a suitable value.

Safety devices are to be provided to prevent each boiler from being fired before the combustion chamber is suitably air scavenged.

3.4.3 Automatic burning installations

Automatic burning installations will be subject to special examination by the Society.

3.4.4 Design of combustion chambers

Combustion chambers are to be so designed as to avoid dead zones where gas might accumulate. The Society reserves the right to require gas detectors in such zones, if these cannot be avoided, and additional air inlets to scavenge these zones if necessary.

4 Use of crude oil

4.1 General

4.1.1 Crude oil may be used as fuel for main or auxiliary boilers and for engines according to the following requirements. For this purpose all arrangement drawings of a crude oil installation with pipeline layout and safety equipment are to be submitted for approval in each case.

4.1.2 Crude oil or slops may be taken directly from cargo tanks or from other suitable tanks. These tanks are to be fitted in the cargo tank area and are to be separated from non-gas dangerous areas by means of cofferdams with gas-tight bulkheads.

4.1.3 The construction and workmanship of the engines and boilers, including their burners, are to be proved to be satisfactory operation with crude oil.

4.1.4 Arrangement are to be made to prevent crude oil effluents or vapours from reaching any gas safe compartment or contaminating non-hazardous fluid systems.

4.2 Arrangement of machinery spaces

4.2.1 Boilers and engines supplied with crude oil are to be located in a dedicated space, referred to as “crude oil machinery space”, separated from other machinery spaces by gas-tight bulkheads. This space is not to contain electric and steam prime movers of pumps, of separators, etc., except when steam temperature is less than 220°C.

4.2.2 The whole system of pumps, strainers, separators and heaters, if any, are to be fitted in the cargo pump room or in another room, to be considered as dangerous, and separated from other machinery spaces by gas-tight bulkheads.

4.3 Pumps

4.3.1 Pumps are to be fitted with a pressure relief bypass from delivery to suction side and it is to be possible to stop them by a remote control placed in a position near the boiler fronts, engine local control position or machinery control room and from outside the machinery spaces.

4.3.2 Where drive shafts pass through pump room bulkhead or deck plating, type-approved gas-tight glands are to be fitted. The glands are to be efficiently lubricated from outside the pump room.

4.4 Heating arrangements

4.4.1 General

All crude oil and slop heating systems are to be built, fitted and tested in accordance with the provisions of Pt C, Ch 1, Sec 7. Refer also to Ch 1, Sec 12, [6.4].

The heating medium temperature is not to exceed 220°C.

Heating pipes, unless otherwise accepted by the Society, are to be fitted with valves or equivalent arrangements to isolate them from each tank and manually adjust the flow.

Means are to be provided to prevent the heating medium supply to the tank heating coils when the product which is not to be heated.

Tank heating system is to be so designed that, when in service, the pressure maintained in the system is higher than that exerted by crude oil.

The heating piping system is to be so arranged as to be easily drained in case of contamination by crude oil.

4.4.2 Observation tank

When crude oil is heated by steam or hot water, the outlet of the heating coils is to be led to a separate observation tank installed together with the components mentioned in [4.2.1].

This tank is to be closed and located in a well ventilated position. It is to be fitted with:

- adequate lighting
- a venting pipe led to the atmosphere in a safe position according to Sect 10 and with the outlet fitted with a suitable flame proof wire gauze of corrosion resistant material which is to be easily removable for cleaning
- arrangements for sampling.

4.4.3 Tank heating arrangements

Heating system pipes are to penetrate crude oil storage tanks only at the top.

Pipes fitted inside tanks are to be of reinforced thickness and built of material suitable for heated fluids. Pipe connections inside crude oil or slop tanks, unless otherwise authorised by the Society, are to be hard-soldered or welded, depending on the type of material.

4.4.4 Control and monitoring

Each tank equipped with a heating system is to be provided with arrangements which permit the measurement of the liquid temperature. Portable arrangements may be used, unless otherwise specified by the Society. In that case, the tank opening is to be of a restricted type.

When it is necessary to preheat crude oil or slops, their temperature is to be automatically controlled and a high temperature alarm is to be fitted.

4.5 Piping system

4.5.1 Pipe thickness

The piping for crude oil or slops and the draining pipes referred to in [4.5.5], [4.6.3] and [4.7.3] are to have a thickness complying with Tab 3.

Table 3 : Minimum thickness of crude oil pipes

External diameter de of pipe, in mm	Minimum thickness t, in mm
de ≤ 82,5	6,3
88,9 < de ≤ 108,0	7,1
114,3 < de ≤ 139,7	8,0
152,4 < de	8,8

4.5.2 Pipe connections

Crude oil pipes connections are to be of the heavy flange type. They are to be kept to the minimum necessary for inspection and maintenance.

4.5.3 Master valve

A quick closing master valve is to be fitted on the crude oil supply to each boiler or engine.

4.5.4 Crude oil return and overflow pipes

Crude oil return and overflow pipes are not to discharge into fuel oil tanks.

Fuel oil delivery to, and returns from, boilers and engines are be effected by means of a suitable mechanical interlocking device so that running on fuel oil automatically excludes running on crude oil or vice versa.

4.5.5 Crude oil draining pipes and drain tanks

Tanks collecting crude oil drains are to be located in the pump room or in another suitable space, to be considered as dangerous. Such tanks are to be fitted with a vent pipe led to the open in a safe position and with the outlet fitted with wire gauze made of material resistant to corrosion and easily dismountable for cleaning.

Draining pipes are to be fitted with arrangements to prevent the return of gas to the machinery spaces.

4.6 Additional requirements for boilers

4.6.1 Piping arrangement

Within the crude oil machinery spaces and other machinery spaces, crude oil pipes are to be fitted within a metal duct, which is to be gas-tight and tightly connected to the fore bulkhead separating the pump room and to the tray. This duct (and the enclosed piping) is to be fitted at a distance from the ship's side of at least 20% of the vessel's beam amidships and be at an inclination rising towards the boiler so that the oil naturally returns towards the pump room in the case of leakage or failure in delivery pressure. It is to be fitted with inspection openings with gas-tight doors in way of connections of pipes within it, with an automatIc closing drain-trap placed on the pump room sIde, set in such a way as to discharge leakage of crude oil into the pump room.

In order to detect leakages, level posItion indicators with relevant alarms arc to he fitted on the drainage tank defined in [4.6.3]. Also a vent pipe is to be fitted at the highest part of the duct and is to be led to the open in a safe position. The outlet is to be fitted with a suitable name proof wire gauze of corrosion resistant material which is to be easily removable for cleaning.

The duct is to be permanently connected to an approved inert gas system or steam supply in order to make possible:

- injection of inert gas or steam in the duct in case of fire or leakage
- purging of the duct before carrying out work on the pipIng in case or leakage.

4.6.2 Shut-off valves

In way of the bulkhead to which the duct defined in [4.6.1] is connected, delivery and return oil pipes are to be fitted on the pump room side, with shut-off valves remotely controlled from a position near the boiler fronts or from the machinery control room. The remote control valves should be interlocked with the hood exhaust fans (defined in [4.6.4]) to ensure that whenever crude oil is circulating the fans are running.

4.6.3 Trays and gutterways

Boilers are to be fitted with a tray or gutterway of a height to the satisfaction of the Society and placed in such a way as to collect any possible oil leakage from boilers, valves and connections.

Such a tray or gutterway is to be fitted with a suitable flame proof wire gauze, made of corrosion resistant material and easily dismountable for cleaning. Delivery and return oil pipes are to pass through the tray or gutterway by means of a tight penetration and are then to be connected to the oil supply.

The tray or gutterway is to be fitted with a draining pipe discharging into a collecting tank complying with the provisions of [4.5.5].

4.6.4 Hoods

Boilers are to be fitted with a suitable hood placed in such a way as to enclose as much as possible of the burners, valves and oil pipes, without preventing, on the other side, air inlet to burner register.

The hood, if necessary, is to be fitted with suitable doors placed in such a way as to enable inspection of and access to oil pipes and valves placed behind it. It is to be fitted with a duct leading to the open in a safe position, the outlet of which is to be fitted with a suitable flame wire gauze, easily dismountable for cleaning. At least two mechanically driven exhaust fans having spark proof impellers are to be fitted so that the pressure inside the hood is less than that in the boiler room. The exhaust fans are to be connected with automatic change over in case of stoppage or failure of the one in operation.

The exhaust fan prime movers are to be placed outside the duct and a gas-tight bulkhead penetration is to be arranged for the shaft.

4.6.5 Gas detection

A gas detection plant is to be fitted with intakes:

- in the duct defined in [4.6.1]
- in the hood duct referred to in [4.6.4]
- in all zones where ventilation may be reduced.

An optical warning device is to be installed near the boiler fronts and in the machinery control room. An acoustical alarm, audible in the machinery space and control room, is to be provided.

4.6.6 Boiler purging

Means are to be provided for the boiler to be automatically purged before firing.

4.6.7 Pilot burner

One pilot burner in addition to the normal burning control is required.

4.6.8 Fire safety

Independent of the fire extinguishing plant as required by Rules, an additional fire extinguishing plant is to be fitted in the boiler room in such a way that it is possible for an approved fire extinguishing medium to be directed on to the boiler fronts and on to the tray defined in [4.6.3]. The emission of extinguishing medium is to automatically stop the exhaust fan of the boiler hood (see [4.6.2]).

A warning notice must be fitted in an easily visible position near the boiler front. This notice must specify that when an explosive mixture is signalled by the gas detector plant defined in M24.13 the watchkeepers are to immediately shut off the remote controlled valves on the crude oil delivery and return pipes in the pump room, stop the relative pumps, inject inert gas into the duct defined in [4.6.1] and turn the boilers to normal running on fuel oil.

4.7 Additional requirements for engines

4.7.1 General

Engines and their crude oil supply system are to comply with the applicable provisions of [4.6] and with the following requirements.

4.7.2 Arrangement of the crude oil piping system fitted to the engine

Crude oil pipes fitted to the engine are to be placed within a duct or covers complying with the provisions of [4.6.1]. However, the duct or covers may not be gas-tight provided that:

- the space within the duct or covers is maintained at a pressure below the pressure in the engine room by means of a mechanical exhaust ventilation system having a capacity of at least 30 changes per hour
- at least 2 exhaust fans are provided with automatic change-over in case of pressure loss
- the fans are of the non-sparking type, and their driving motor are placed outside the duct
- the temperature within the duct or covers is well below the self-ignition temperature of the crude oil
- a pressure sensor is fitted inside the duct or covers to detect any vacuum loss
- a system is provided to detect the presence of crude oil vapour in the duct or covers
- a flame arrester is fitted on the duct venting outlet.

4.7.3 Arrangement for oil leakage collection and detection

Gutterways or suitable grooves are to be arranged in way of the engine crude oil piping for the collection of possible leakages. They are to discharge into a detection well fitted with a high level alarm.

The detection wells are to be fitted with a draining pipe discharging into a collecting tank complying with the provisions of [4.5.5].

4.7.4 Gas detection

Gas detectors are to be fitted:

- in the duct or covers referred to in [4.7.2]
- in all zones where ventilation may be reduced.

4.7.5 Safety arrangements

The crude oil supply is to be shut-off and the engine switched over to fuel oil in the following cases:

- vacuum loss (see [4.7.2]
- crude oil detection (see [4.7.3])
- vapour detection (see [4.7.4]).

4.7.6 Fire safety

The duct or covers are to be fitted with a suitable fire-fighting system.

Where the duct or covers are not gas-tight, the fire-fighting system is to be of the spray water system.

SECTION 14 SWIVELS AND RISERS

1 Swivels

1.1 Pressure swivels

1.1.1 The pressure parts of a pressure swivel are to be designed and manufactured according to the requirements of Pt C, Ch 1, Sec 3 of the Ship Rules or other recognised pressure vessel code.

1.1.2 A pressure swivel is to be isolated from the structural loads due to the anchoring systems.

1.1.3 Piping loads on swivel are to be minimised (e.g. by means of an expansion joint).

1.1.4 Materials of swivel and seals are to be compatible with transported products.

1.1.5 Bearings are to be protected against internal fluids and marine environment. Bearings are to be designed for the rated life of the swivel.

1.1.6 If necessary, pressure seals are to be protected against mechanical aggression.

1.1.7 The sealing system of flammable or toxic products is to constitute, at least, a double barrier against leakage to environment or, for multiple product swivels, between the different products.

Means are to be provided to allow the checking of the sealing system integrity with the swivel in operation. A leak detection and alarm system is to be provided.

1.1.8 Means are to be provided to collect and safely dispose of liquid leaks of flammable products.

1.2 Electrical swivels

1.2.1 Electrical swivels are to be designed and manufactured according to the applicable requirements of Part C, Chapter 2.

1.2.2 Where relevant, electrical swivels are to be suitable for the hazardous area in which they are located.

1.3 Test of pressure swivels

1.3.1 Static resistance tests

A pressure swivel is to be subjected to a pressure resistance static test, according to its design code.

1.3.2 Dynamic tests

Rotation and oscillation tests including rest periods are to be performed at design pressure with measurement of starting and running moments.

At least two complete rotations, or equivalent, in each direction are to be performed. The rotation speed is to be around 1°/s.

1.4 Tests of electrical swivels

1.4.1 Static tests

An electrical swivel is to be subjected to dielectric and insulation resistance tests in accordance with Part C, Chapter 2 and IEC 502.

1.4.2 Dynamic tests

A continuity test is to be performed with the swivel in rotation.

2 Marine risers systems

2.1 General

2.1.1 Application

In principle, the limit of classification is the connector of the riser with the pipeline end manifold.

Other limits may be agreed upon and in this case will be specified on the Certificate of Classification.

The provisions of the present [2] are only applicable to marine riser systems connecting production or storage units to sea-bottom equipment and export lines when the **RIPRO** additional class notation is requested.

2.1.2 Definitions

a) Riser system

The riser system includes the riser itself, its supports and all integrated riser components.

b) Riser

The riser is the rigid or flexible pipe between the connectors located on the unit and on the sea bottom.

c) Riser components

The riser components are all the equipment associated with the riser such as clamps, connectors, joints, end fittings, bend stiffeners.

d) Riser supports

The riser supports are the ancillary structures giving the riser its configuration and securing it to the unit and to the sea bed, such as buoyancy modules and sinkers, arch systems, anchor points, tethers, etc.

2.2 Riser system design

2.2.1 Risers are subject to actions of currents and waves along the line, and primarily, to imposed displacements of riser head attached to the unit. Design analyses are to be carried out in order ascertain that the design configuration is appropriate and in order to verify that extreme tensions, curvatures, and cyclic actions are within the design limits of the specified product.

The load cases selected for analysis are to be verified as being the most unfavourable combinations of vessel offsets and current / wave loadings.

An analysis of interference is to be performed in order to verify that all the risers, umbilical and anchor lines remain at an acceptable distance from each other (and from the unit) during operation.

The fatigue life of the riser is to be assessed.

2.3 Riser and riser components

2.3.1 Each marine riser is to be designed, fabricated, tested and installed in accordance with the requirements of a recognised standard, submitted to the agreement of the Society, such as:

a) For rigid riser systems:
   - ANSI B 31.4 "Liquid transportation systems for hydrocarbons, liquid petroleum gas, anhydrous ammonia and alcohols"
   - ANSI B 31.8 "Gas transmission and distribution piping systems"
   - BS 8010 "Code of practice for pipelines"
   - API RP 2RD "Design of Risers for Floating Production Systems (FPSs) and Tension-Leg Platforms (TLPs)
   - API RP 1111 "Design, Construction, Operation and Maintenance of Offshore Hydrocarbon Pipelines (Limit State Design).

b) For non-bonded flexible riser systems:
   - Guidance Note NI 364 "Non-Bonded Flexible Steel Pipes Used as Flow-Lines"
   - API Spec 17J "Specification for Unbonded Flexible Pipes"
   - API RP 17B "Recommended Practice for Flexible Pipe".

c) For bonded flexible riser systems:
   - OCIMF "Guide to Purchasing, Manufacturing and Testing of Loading and Discharge Hoses for Offshore Moorings" within 100 m waterdepth
   - API Spec 17K "Specification for bonded flexible pipe".

2.4 Riser supports

2.4.1 Equipment for supporting of risers are to be designed in accordance with the relevant provisions of Part B, Chapter 3.

2.4.2 Steel cables and fibre ropes used as tethers and associated fittings are to be designed and constructed in accordance with the relevant provisions of Guidance Note NI 493 "Classification of Mooring Systems for Permanent Offshore Units".