Rules for the Classification of Offshore Units

PART D – Service Notations

Chapter 1
ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine & Offshore Division (the "Society") is the classification ("Classification") of any ship or vessel or offshore unit or structure of any type or part of it or system therein collectively hereafter 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, machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

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, instrumen-
tation, 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 chart-
tering, 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 sur-
evies for the Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisement is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

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

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

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

ARTICLE 3

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

3.2. - The Client is responsible for ensuring that the Units related to the Services are not subject to any applicable or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value that may not appear in other documents issued by the Society.

3.3. - The Client is responsible for authorising and certifying that the Units are the subject of any surveys, tests or trials that may appear in other documents issued by the Society.

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.

4.2. - 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 of vessels, 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 im-
plied 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 construc-
tion in conformity with its design, that being the exclusive responsibility of its owner or builder.

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any sur-
vey 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 their omission or loss 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 thou-
sand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one a half times the above mentioned fee. These limits apply regardless of fault in-
cluding breach of contract, breach of warranty, tort, strict liability, breach of statute, etc.

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

ARTICLE 7

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

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

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. here above subject to compliance with 2.3. here above and Article 9 hereunder.

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

ARTICLE 8

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

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

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 protected 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 classifica-
tion 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;

* copies of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society, where appropriate, in case of the Unit's transfer of class;

* the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units, as well as general technical information related to hull and equipment damages, may be passed on to IACS (International Association of Classification Societies) according to the association working rules;

* the certificates, documents and information relative to the Units classed with the Society may be reviewed during certificating bodies audits and are disclosed upon order of the concerned government-
al 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 So-
ciety may designate another of its surveyors at the request of the Client.

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

ARTICLE 12

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

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

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

ARTICLE 13

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

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the va-
lidity 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.

MARINE & OFFSHORE DIVISION
GENERAL CONDITIONS
RULES FOR THE CLASSIFICATION OF OFFSHORE UNITS

Part D
Service Notations

Chapter 1

Chapter 1  PRODUCTION, STORAGE AND OFFLOADING SURFACE UNITS

December 2016
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 December 1st, 2016. The Society may refer to the contents hereof before December 1st, 2016, as and when deemed necessary or appropriate.
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SECTION 14 SWIVELS AND RISERS
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 be assigned with one of the notations listed in [1.2.1].

1.1.2 Units intended to be assigned with the service notations liquified gas storage and/or gas liquefaction, as defined in Pt A, Ch 1, Sec 2, [5], are to comply with NR542, Classification of Offshore Floating Gas Units.

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

1.2 Class Notations

1.2.1 Structural type notations

Requirements of the present Chapter apply to surface units having one of the following structural type notations:

- offshore service barge - which may be granted to surface type floating units, including the case of converted ships, when unable to perform non-assisted voyages.
- offshore service ship - which may be granted to surface type floating units having a propulsion system and steering appliances for transit purpose, but not involved in the transport of cargoes, as defined in [3.2.14].

Note 1: The notation oil tanker ESP/offshore service ship may only be granted to oil tankers used as offshore floating production and/or storage units, being able to perform non-assisted voyages involving transport of cargoes as defined in [3.2.14].

When the notation oil tanker ESP or a combination hereof is granted, the requirements of the Ship Rules related to this notation are also to be complied with.

1.2.2 Service notations

This Chapter applies to units having at least one of the following service notations:

- oil storage - which may be granted to surface units engaged in the storage of oil products (in significant quantities).
- production - which may be granted to surface units designed and equipped for oil production and related activities.

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

1.2.3 Site, transit and navigation notations

Site, transit and navigation notations are granted in accordance with the provisions of Pt A, Ch 1, Sec 2, [7].

1.2.4 Additional service features

The following additional service features defined in Pt A, Ch 1, Sec 2 are mandatory for units covered by the present Chapter:

- POSA, POSA HR or POSA JETTY
- INERTGAS (mandatory for units with service notation oil storage and for units with service notation production having integrated process tanks)

1.2.5 Additional class notations

The following additional class notations are mandatory for units covered by the present Chapter:

- AUTO
- INWATERSURVEY (mandatory for permanent units)
- VeriSTAR-HULL

Other additional class notations defined in Part A may be granted to units covered by the present Chapter.

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

1.2.6 Comfort on board floating units

The notations dealt with under this heading are relevant to the assessment of comfort and health 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, are 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 notations COMF HEALTH-NOISE-g and COMF HEALTH-VIB-g given in NR636 are to be considered. The Society is to take into account realistic criteria upon the final evaluation of the unit and based on the Owner requirements.
1.3 Scope

1.3.1 Classification Society involvement

The scope of classification for units listed in [1.2.1] 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:
   - for the additional service feature POSA:
     mooring line components (anchors, chains, wire and accessories) and hull mounted equipment (fairleads, stoppers...)
   - for the additional class notation OHS:
     mooring line handling equipment (winch, sheaves...)
f) Lifting appliances (for 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 present Rules and related applicable Rules (taking into account the class notations AUTO, INERTGAS and 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 items g), h), i), j) and k) above are possibly positioned in topsides facilities and remain under the scope of classification, regardless of the additional class notation PROC (see also [1.8.2]).

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

1.3.2 Classification - Design Criteria Statement

Classification is based upon the design data or assumptions specified by the party applying for classification.

A Design Criteria Statement is to list the services performed by the unit and the design conditions and other assumptions on the basis of which class is assigned to the unit.

The Design Criteria Statement is to be:

- issued by the Society
- referred to on the unit classification certificate
- incorporated in the Operating Manual, as stated in Pt A, Ch 1, Sec 1, [3.4].

Additional details about the Design Criteria Statement are given in Pt A, Ch 1, Sec 1, [1.6].

1.3.3 Classification process

For units intended to have one of the notations given in [1.2.1] except a combination with oil tanker ESP, the classification process, prior to issuance of the final class certificate, includes towing from completion yard to site (see 1.10), hook-up operations and commissioning at site.

For units intended to have the notation oil tanker ESP or a combination hereof, the classification process may lead to issuance of the 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/transit, 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 parties involved. Basing on these documents, the Society prepares the survey program for inspection and drawing review.

1.3.4 Classification - Surveys during service

When the notation oil tanker ESP/offshore service ship is granted, the requirements for survey of ships having 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 the bottom survey in dry-dock to be replaced by in-water survey.

For units having a notation not including oil tanker ESP, the Society considers the same survey requirements as for oil tanker ESP and adapts the required surveys to the specifications of the units in terms of operational conditions, which are to be documented and made available to the Society.

Prior to a unit entering into service:

- a classification renewal plan listing the survey plan for the five-year classification period is to be submitted to, and approved by, the Society
- regarding the mooring lines (within the scope of additional service feature POSA), the Inspection, Maintenance and Repair (IMR) plan for the station keeping system is to be agreed with the Society.

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 from either the date of the initial classification or the credited date of the last class renewal survey, and is generally equal to 5 years.
1.3.5 Permanent installations
Surface units having one of the notations given in [1.2.1] are considered as permanent installations when performing their service either:

- at a single location, or
- on a single site for a duration not less than, typically, 5 years.

Two types of permanent installations are to be considered:

- disconnectable, when the unit has a means of disengaging from its mooring and riser systems in extreme environmental or emergency conditions
- non-disconnectable.

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

1.3.6 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 and may influence not only the design but also the in-service inspections.

1.4 Applicable rules

1.4.1 General application of the Rules
The provisions of these Rules are applicable to the design and construction of newbuild surface units and to reassessment and conversion work of an existing unit or ship when converted to a unit covered by the present document (see also [1.5.3]).

When reference is made to “Ship Rules”, it means the Rules for Steel Ships (NR467), and the applicable version of these “Ship Rules” (see definition in [3.2.6]) is the latest one.

In case of converted ships, the Society reserves its right to refer to previous editions of the Ship Rules.

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

1.4.2 Hull structure
The Sections to be applied for the hull scantling and arrangement are given in Tab 1.

Table 1: Sections applicable for hull scantling

<table>
<thead>
<tr>
<th>Part</th>
<th>Applicable Sections or Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Ch 1, Sec 1</td>
</tr>
<tr>
<td>Specific</td>
<td>Ch 1, Sec 8, [3]</td>
</tr>
</tbody>
</table>

1.4.3 Other structure
The Articles to be applied for the scantling and arrangement of specific structures are given in Tab 2.

Table 2: Articles applicable for scantling of other structures

<table>
<thead>
<tr>
<th>Item</th>
<th>Applicable Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superstructures and deckhouses</td>
<td>Ch 1, Sec 8, [5]</td>
</tr>
<tr>
<td>Station keeping</td>
<td>Ch 1, Sec 8, [1]</td>
</tr>
<tr>
<td>Topside</td>
<td>Ch 1, Sec 8, [2]</td>
</tr>
<tr>
<td>Helicopter decks</td>
<td>Ch 1, Sec 8, [6]</td>
</tr>
<tr>
<td>Boat landing</td>
<td>Ch 1, Sec 8, [7]</td>
</tr>
<tr>
<td>Hull outfitting</td>
<td>Ch 1, Sec 8, [7]</td>
</tr>
</tbody>
</table>

1.5 Structural requirements

1.5.1 Definition
Surface units are in principle similar to oil trading tankers, the main differences being in the following parameters:

- specific site as opposed to ocean trading
- towing or transit limited to voyage between the constructing shipyard and the 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 design life
- units permanently moored.

The related documentation is to be made available to the Society for reference.

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

a) Classification marks and notations
b) Environmental conditions (transit/towing phases, site)
c) Production effects (lightweight, loading cases).

When a navigation notation completes the site and/or transit notations (as defined in Pt A, Ch 1, Sec 2, [7]), the estimated loads and motions from the hydrodynamic analysis are to be compared to the rule values given for the granted navigation notation in order to determine the rule design loads and motions.

A Design Criteria Statement, as defined in [1.3.2], 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 design life with possible objective of no dry-docking during this period, accessibility for in-service inspections is to be considered during the detailed design phase.

1.5.3 Conversion, redeployment or life extension of existing units
As a rule, structural reassessment is mandatory in case of redeployment, life extension or conversion work of existing units or ships (see NI 593).
A feasibility study is required for projects based on conversion of existing seagoing ships into units intended to have one of the notations 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.

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

a) still water conditions
b) extreme environmental conditions during unit operation (100-year wave)
c) offloading conditions
d) limiting conditions before the disconnection from a single point mooring, if relevant
e) conditions during maintenance or inspection operations
f) transit/towing conditions, from the construction/conversion location to offshore site and between the different construction shipyards, when relevant
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.

1.5.5 Hull attachments and appurtenances
Loads on the hull are to be clearly identified by the shipyard or the 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 of 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 the scope of Classification if the supported equipment is either within the scope of Classification or essential for the safety of the unit. Otherwise, the interface between classed and non-classed parts is to be defined on a case-by-case basis.

1.5.6 Definition of ship areas
For the hull construction, and similarly to the approach for the design detailed in the present Rules, the shipbuilding practice, the industry and regulatory requirements and the Ship Rules (as defined in [3.2.6]) are the base references for the construction of the hull current parts, including materials, details, welding qualification, fabrication tolerances and inspection (see Ch 1, Sec 3, [2.3]). Any deviation from these standards is to be clearly documented on the construction drawings and in the specifications.

When the Ship Rules are applied for the design of the hull current parts, attention is to be paid to the loads specified in [1.5.4].

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

1.5.7 Definition of offshore areas
For the areas specific to offshore service, such as the elements listed in Ch 1, Sec 3, Tab 1, reference is made to Part B. More details are given in Ch 1, Sec 3, [2.2].

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.

1.6 Design life
1.6.1 The requirements about the design life, unit modifications and unit re-assessment are given in Pt A, Ch 1, Sec 1, [1.7].

1.7 Station keeping
1.7.1 General
The additional service features POSA, POSA HR and POSA JETTY cover 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 NR493.

Note 1: Classification of the position mooring equipment is mandatory for permanent units.

The station keeping of the unit may be reached by different design configurations, which are subject to review, on a case-by-case basis:

a) The floating structure may use catenary, taut spread moorings and/or dynamic positioning systems. Mooring lines may be either combined into a turret base (SPM – Single Point Mooring) with a single point of contact to the hull of the floating unit, or connected to the hull in more than one position (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) The mooring system may be based on use of the Catenary Anchor Leg Mooring (CALM) concept (pendulum link or rigid arm connection to the hull of the floating unit).

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

The structural 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 NR493.
When the station keeping of the unit is achieved by means of a turret, the turret structure 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].

1.7.2 Dynamic positioning systems
The mooring system may consist, either partly (combined with passive mooring systems as described in [1.7.1]) or entirely, in dynamic positioning systems, for which reference is made to the requirements given for additional class notation DYNAPOS in the Ship Rules, Pt E, Ch 10, Sec 6.

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

The buoy, mooring system included, is to be classed by the Society. The additional service feature POSA is to be granted to the buoy.

The arrangement of the buoy is to comply with NR494, Rules for the Classification of Offshore Loading and Offloading Buoys.

1.7.4 Single Point Mooring
For mooring to an existing Single Point Mooring (SPM) (possibly classed by another Classification Society), detailed documentation of the SPM is to be submitted to the Society for review. This documentation is to include certificate, design and maintenance. The Society reserves the right to require complete re-classification of the installation, including remeasurement of lines and anchors.

1.8 Scope of additional class notations

1.8.1 Classed topsides - Notation PROC
The structure of topside modules supporting entirely the 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 the additional class notation PROC is granted, the structure of deck modules, flare boom and other structures housing production equipment, as well as related facilities, are to be designed and built in accordance with the relevant requirements of Part B, Chapter 2 and Part B, Chapter 3.

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

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

The classification covers the equipment necessary to the proper operation of these systems, as requested by the Rules and other related applicable rules or standards.

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

Particular attention is to be paid to the design of the pipe rack on the main deck, which remains within the scope of classification, regardless of the presence of pipes serving the topsides process plants.

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

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1.8.3 Riser attachment - Additional class notation RIPRO

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

In case the additional class notation RIPRO 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, the additional class notation RIPRO being or not being requested.

Equipment fitted onboard for the installation of risers are considered as outside the scope of classification unless requested by the Owner or unless an additional class 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 breaking strength of the wires used during installation.

1.8.4 Lifting appliances - Additional class notations ALP, ALM and ALS

The additional class notations ALP, ALM and ALS may be assigned to units equipped with cranes and other lifting appliances meeting the relevant requirements of NR526, Rules for the Certification of Lifting Appliances onboard Ships and Offshore Units.

When no additional class notation for lifting appliances is granted, the classification covers only the crane pedestal and its foundation welded to the hull, considering the loads specified by the designer.

When the crane pedestal and its foundation are welded to a classed topside structure covered by the notation PROC, they are covered by class for the specific loads provided by the designer.

When one of the additional class notations ALP, ALM and ALS is granted and the crane pedestal is partially or completely supported by a topside structure not covered by class (notation PROC not requested), the crane pedestal and its foundation are not covered by class. In case the pedestal is connected to the topside structure and extended over the hull, only the part of pedestal connected to the hull is classed for the 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 the additional class notations ALP, ALM and ALS, the construction mark as defined in Pt A, Ch 1, Sec 2 is required.

1.9 Classification and temporary conditions during construction

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

1.9.2 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 the hull leaving the yard.

1.10 Classification and towing/transit

1.10.1 General

The towing or sailing by means of own propulsion system, between the construction shipyard and the intended site, is covered by classification requirements. To flag the unit is:

• recommended for the towing
• mandatory in international waters and when people is onboard. Attention is to be paid to the compliance with international codes and standards as required by National Authorities.

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

1.10.2 Temporary conditions

Provisions for the temporary conditions during construction and transit are defined in [1.9.1].

1.10.3 Environmental conditions for towing/transit

The Society may require:

• detailed documentation for the intended route between the construction shipyard and the intended site, and
• further investigation of slamming loads, green waters, bow impact and ice loads, if any, depending on the severity of the intended route, the planned period of the year and duration for the towing.

Extreme loads for towing/transit are to be taken by default for a return period of 10 years (typically referred to as a probability level of $10^{-7}$). Different values may be considered if specified by the party applying for classification.

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

1.10.4 Fatigue strength during towing/transit

The Society reserves the right to require, for structural members, a direct fatigue analysis resulting from the towing/transit. Such fatigue analysis is to be combined with the overall fatigue verification of the unit in operation at intended site.

1.10.5 Temporary mooring during towing/transit

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

2 Statutory requirements

2.1 General

2.1.1 Project specification

Prior to commencement of the review of drawings, the complete list of Regulations, Codes and Statutory Requirements to be complied with is to be submitted for information:

- International Regulations
- Flag State requirements
- Coastal State requirements
- Owner standards and procedures
- Industry standards.

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

2.1.2 Conflict of Rules

In case of conflict between the present 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.

2.2 International Convention on Load Lines

2.2.1 Application

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

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

Application of ILLC has an impact on the stability requirements (see Ch 1, Sec 2).

2.2.2 ILLC at site

The Society verifies that the maximum draught of the unit is equal to, or less than, the draught derived from the Load Line Convention requirements, as applicable to tankers.

2.3 MARPOL 73/78

2.3.1 Application

The Society recommends to apply the “Guidelines for application of the revised MARPOL Annex 1 requirements to FPSOs and FSUs” issued by IMO as document MEPC 139(53) and MEPC 142(54).

2.4 SOLAS

2.4.1 Application

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

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

2.5 IMO MODU

2.5.1 Application

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

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

3 Symbols and definitions

3.1 General

3.1.1 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.

3.2 Definitions

3.2.1 Floating production units

A floating production unit (FPU) is a unit fitted with processing equipment necessary to perform basic treatment (dewatering, degassing, gas compression, etc.) of hydrocarbons received from wells.

3.2.2 Floating storage units

A floating storage unit (FSU) is a surface unit intended for the storage in bulk of liquid cargoes as defined in [3.2.14].
3.2.3 Floating storage and offloading units
A floating storage and offloading unit (FSO) is a unit fitted with equipment for offloading stored hydrocarbons by shuttle tankers, 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).

3.2.4 Floating production, storage and offloading units
Production and storage installations may be combined into floating production and storage units (FPSU) or into floating production, storage and offloading units (FPSO).

3.2.5 Station keeping
A floating production and/or storage unit may be kept in position by means of either:
- a single point mooring at which the unit is moored or articulated, or
- an independent anchoring system, or
- a dynamic positioning system.

When provided, the anchoring system may consist in 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 are able to sail the 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.

3.2.6 Ship Rules
Following [1.4.1], when “Ship Rules” are mentioned in the present Rules, reference is made to Rule Note NR467, Rules for the Classification of Steel Ships. The applicable requirements are those for ships greater than 65 m in length. The designer has to contact the Society for information about the latest applicable version of these Rules.

3.2.7 Rule length
For surface units, the rule length $L$ is determined, for transit and site conditions, similarly to seagoing oil tankers (see the 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.

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

For units articulated around a single point mooring, the fore part is the part next to this single point mooring.

During transit, the fore part is the one orientated in the direction of towage.

3.2.9 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, dedicated machinery spaces are provided for essential generators, etc.

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

3.2.10 Topsides
A topside structure is usually an independent structure located on the deck of the floating unit (typically the freeboard and strength deck). Depending on 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 the scope of classification. The Society may require detailed documentation for information.

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

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

The maximum site draught is the deepest draught able to be observed during operation.

The minimum site draught is the lightest draught able to be observed during operation.

3.2.12 Transit draughts
For any transit phase, a maximum draught and a minimum draught are to be determined by the designer and reflected in the associated loading conditions.

3.2.13 Splash zone
The “splash zone” is the zone of the floating structure which is alternately in and out of water due to wind, waves and motions. Areas which are wetted only in case of major storms are excluded from the splash zone.

The exact location and vertical extent of the splash zone are to be determined at the design stage as a 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 up to 5 m above the maximum loaded draught.

Corrosion in the splash zone during service is to be prevented by means of protective coating systems and/or corrosion margins and thickness increments of the plating.
3.2.14 Cargo
For the application of this Chapter, cargo means all the oil-like liquids in relation with the drilling and process (production) operations 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.

3.2.15 Corrosion addition
The corrosion addition is the thickness to be added to the net thickness in view of corrosion allowance, as defined in Ch 1, Sec 3, [4].

3.2.16 Thickness increment
The thickness increment is the thickness that may be added to the gross thickness, in accordance with Ch 1, Sec 3, [5].

3.2.17 Manned end
The manned end is the end of the unit where accommodation is located.

3.2.18 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.

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

3.2.20 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.

3.2.21 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.

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

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

3.2.24 Separate piping system
A separate piping system is 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.

3.2.25 Process tank
A process tank is an internal tank used in the hydrocarbon production and processing systems which may contain a highly corrosive mixture of oil, gas, water, mud and chemicals.

3.2.26 Cargo area
The cargo area is that part of the unit which contains cargo tanks, slop tanks, process tanks, cargo pump rooms, cofferdams, ballast and void spaces adjacent to cargo tanks as well as deck areas throughout the entire length and breadth of the unit above the mentioned spaces.

For the purpose of the present Chapter, cargo area and storage area have the same meanings (see [3.2.27]).

3.2.27 Storage area
For the purpose of the present Chapter, storage area and cargo area have the same meanings (see [3.2.26]).

3.3 Reference co-ordinate system

3.3.1 The ship geometry, motions, accelerations and loads are defined with respect to the following right-hand co-ordinate system (see Fig 3):
- Origin: at the intersection between the ship longitudinal plane of symmetry, 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.

Figure 3 : Reference co-ordinate system

4 Calculations

4.1 Calculations to be submitted

4.1.1 Procedures
Procedures and assumptions used 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 calculations are to be submitted:

- **Hydrodynamic calculations:**
  - direct calculation report
  - model test report and calibration report, if relevant
- **Finite element calculations:**
  - primary supporting members of cargo tanks
  - topside supports
  - turret supports
  - spread mooring seats
  - fatigue structural details
  - topsides, when PROC notation is granted
  - spectral fatigue when Spectral Fatigue notation is granted
- **Additional calculation reports are recommended and should be submitted for information when they are performed:**
  - dropped object analysis procedure
  - collision analysis procedure
  - explosion analysis procedure
- Calculation of design temperature of structural elements, if relevant (see Ch 1, Sec 3).

Detailed documentation of software used, demonstrating calculation accuracy, may be requested by the Society.

**4.1.2 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 are to be available.

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

Graphically, information for several loading conditions is to show deformation of structure and Von Mises stress values.

**5 Design criteria and data**

**5.1 General**

**5.1.1** 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.

**5.2 Site data**

**5.2.1** 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: Units intended to operate on several sites or units not being permanent installations are specially considered.

**5.3 Operating loading conditions**

**5.3.1 General**
The data on unit operation are to include the information required from [5.3.2] to [5.3.5].

**5.3.2 Cargoes and processed products**
Characteristics of processed hydrocarbons and cargoes intended to be stored (in particular H₂S content).

**5.3.3 Environmental conditions**

a) Extreme environmental conditions during unit operations
b) Most severe environmental conditions, if relevant, during offloading operations towards a shuttle tanker, moored alongside or in tandem mode
c) Limiting conditions before disconnection from the single point mooring, if relevant
d) Most severe environmental conditions, if relevant, during maintenance operations such as dismantling of main bearings of connection with the single point mooring
e) Environmental conditions during towing/transit from construction/conversion location to offshore site, when not covered by a navigation notation.

**5.3.4 Loads**

a) loads induced by connection to a Single Point Mooring, if any, in all relevant conditions detailed in [5.3.3], 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 tankers
d) loads induced by process and other equipment.

**5.3.5 Loading conditions**
The following loading conditions 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, such as light ballast, or tank cleaning/inspection, and related limiting conditions for environment
c) loading condition for towing/transit.

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

**6 Documentation to be submitted**

**6.1**

**6.1.1** The documentation to be submitted is to include the following information, in addition to the documentation required in Part A, Chapter 1:

a) Design criteria and data, as defined in [5]
b) Data for hydrodynamic analysis:
   - lines plan and appendices on hull
   - environmental data as required in Pt B, Ch 2, Sec 2
   - properties of the unit related to the assessment of wind and current loads (areas, coefficients), when a heading analysis is performed (see Ch 1, Sec 4)
   - properties of mooring system and relevant information
• loading manual with description of each loading condition

c) General drawings:
• general arrangement of the unit, showing, as relevant:
  - location of the storage tanks with their openings, ballast tanks, cofferdams and void spaces, accesses to hazardous and safe spaces, cargo storage, 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

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

e) Machinery and piping drawings:
• oil and gas processing plant (general arrangement, PID)
• cargo offloading equipment
• gas disposal system
• diagram of cargo and gas piping systems, including offloading piping
• connections to risers
• diagram of stripping system for cofferdams, pump rooms and other spaces within the storage area
• diagram 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

f) Inert gas installations:
• single-wire diagram of the installation, together with the following main characteristics: capacity, pressure, temperature, O₂ content, water content
• list of the components (with their characteristics) of: pipes, scrubber, blowers, non-return devices, valves, pumps, protective devices for overpressure and vacuum
• general arrangement plan of installations on board
• diagram of monitoring and alarm systems
• specifications of O₂ analyser, recorder and portable control instruments

g) Safety plans:
• drawing and specification of fire and gas detection systems
• fire protection details in accommodation areas
• fire extinguishing systems in machinery and accommodation areas
• foam extinguishing systems within storage area: general arrangement diagram, calculation note, foam agent specification, characteristics of foam monitors and hoses
• fire-extinguishing system in cargo pump rooms: general arrangement plan and calculation note
• fire-extinguishing system in process areas

h) Others:
• documents relevant to contemplated additional class 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 covered by the present Chapter (see Ch 1, Sec 1, [1.2.1]) and intended to receive the service notation oil storage.

1.1.2 Units covered by the present Chapter but not intended to receive the service notation oil storage are to comply with the requirements of Part B, Chapter 1 instead of the present Section.

1.1.3 Provisions of the Ship Rules applicable to oil tankers are also applicable to units intended to be granted a notation including oil tanker ESP/offshore service ship.

2 Stability

2.1 Free surface effect

2.1.1 General

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.

Free surface effects are to be considered whenever the filling level in a tank is less than 98% of full condition. Free surface effects need not be considered where a tank is nominally full, i.e. filling level is 98% or above.

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

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

2.1.2 Gutter bars

Where gutter bars are provided on the cargo tank deck in order to avoid the spillage of flammable liquids, as required by Ch 1, Sec 10, [1.7], the free surface effect caused by containment of cargo spill, boarding seas or rain water is to be considered with respect to the vessel’s available margin of positive initial stability (GMo).

Gutter bars are not to be accepted without an assessment of the initial stability (GMo) for compliance with the relevant intact stability requirement taking into account the free surface effect caused by liquids contained by the gutter bars.

2.1.3 Documentation to be submitted

A stability file is to be submitted by the Owner or its representative. It has to 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 to be complied with. In addition, the following requirements are applicable:

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/towing condition
- selected operational loading conditions covering foreseen fillings of the cargo tanks. One of the conditions must 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 \( l_c \):
  \[ l_c = \frac{1}{3} L_{LL}^{1/3} \text{ or } 14.5 \text{ m}, \text{ whichever is the lesser} \]
- transverse extent \( t_c \), measured inboard from the side shell plating, at right angle to the centreline, at the level of summer load line:
  \[ t_c = \frac{B}{5} \text{ or } 11.5 \text{ m}, \text{ whichever is the lesser} \]
- vertical extent \( v_c \), from the moulded line of the bottom shell plating at centreline: upwards 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

3.1 General

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

3.2 Cargo tanks

3.2.1 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.

3.2.2 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.

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

3.2.4 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].

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

3.3 Location and arrangement of spaces adjacent to storage area

3.3.1 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.

Note 1: Pump-rooms intended solely for ballast transfer need not comply with the requirements of Ch 1, Sec 10, [1.2]. The requirements of Ch 1, Sec 10, [1.2] are only applicable to the pump-rooms, regardless of their location, where pumps for cargo, such as cargo pumps, stripping pumps, pumps for slop tanks, pumps for COW or similar pumps are provided.

“Similar pumps” includes pumps intended for transfer of fuel oil having a flashpoint of less than 60°C. Pump-rooms intended for transfer of fuel oil having a flashpoint of not less than 60°C need not comply with the requirements of regulation Ch 1, Sec 10, [1.2].

3.3.2 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 [3.3.1] 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.

3.3.3 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.
3.3.4 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 [3.3.2] need not be taken into account when the position of these spaces is being determined.

3.4 Cargo pump rooms

3.4.1 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.

3.4.2 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.

3.5 Drainage arrangements and slop tanks

3.5.1 Drainage arrangements

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

3.5.2 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.

3.5.3 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.

3.5.4 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.

3.6 Ballasting of double bottom and narrow tanks

3.6.1 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.

3.7 Collision bulkhead

3.7.1 A collision bulkhead is to be provided, when necessary, to prevent flooding during transit and/or site conditions. The collision bulkhead is to comply with the requirements of the Ship rules.

3.7.2 Subject to the agreement of the flag Administration, if any, the Society may accept an exemption from having a collision bulkhead when the risk of collision is mitigated and duly justified (collision analysis, external turret, damage stability ...).

3.7.3 Subject to the agreement of the flag Administration, if any, the Society may, on a case by case basis, accept a distance from the collision bulkhead to the forward perpendicular FPLL greater than the maximum specified in the Ship rules, provided that subdivision and stability calculations show that, when the unit is in upright condition on full load draft, flooding of the space forward of the collision bulkhead will not result in any part of the freeboard deck becoming submerged, or in any unacceptable loss of stability.

3.8 Aft peak bulkhead

3.8.1 General

As a rule, offshore units are to be provided with an aft peak bulkhead in accordance with the Ship rules, except when the risk of collision is mitigated and duly justified (collision analysis, external turret, damage stability ...).
SECTION 3  STRUCTURE DESIGN PRINCIPLES

1  Definition of the unit areas

1.1  Principles

1.1.1  General
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”. 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>
<thead>
<tr>
<th>Elements Area</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flare tower supports</td>
<td>Offshore area</td>
</tr>
<tr>
<td>Turret moon pool, casing, and surrounding area</td>
<td></td>
</tr>
<tr>
<td>Topsides supports at main deck</td>
<td></td>
</tr>
<tr>
<td>Crane pedestals and foundation into hull</td>
<td></td>
</tr>
<tr>
<td>Helideck support structure</td>
<td></td>
</tr>
<tr>
<td>Mooring supports</td>
<td></td>
</tr>
<tr>
<td>Hose handling crane pedestal and foundation into hull</td>
<td></td>
</tr>
<tr>
<td>Offloading equipment foundations</td>
<td></td>
</tr>
<tr>
<td>Riser porches and their foundations to the hull</td>
<td></td>
</tr>
<tr>
<td>Foundations of riser and mooring lines tensioning systems</td>
<td></td>
</tr>
<tr>
<td>Towing brackets and their foundations</td>
<td></td>
</tr>
<tr>
<td>Other elements</td>
<td>Ship area</td>
</tr>
</tbody>
</table>

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 areas are 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 strength requirements for ship areas (see [1.1.3]).

1.1.3  Ship area requirements
Ship areas listed in Tab 1 are to be in accordance with Part B and Part D, Chapter 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
The offshore areas always include the following items:

- the foundations of modules and equipment defined in Tab 1 and their additional local structural members
- the inserts in primary supporting members, decks, bulkheads and side shell
- the reinforced longitudinal stiffeners
- the partial stringers, deck girders and web frames.

For other members and when the limits of offshore area is not obvious from engineering judgment, the offshore area is to be extended up to a distance where the equivalent membrane stress is lower than 30 MPa when only appurtenance forces are applied.

1.1.5  Structural categories for offshore areas
Offshore areas are divided into three categories (special, first and secondary) for the structural members. These categories are defined in Pt B, Ch 3, Sec 2, [2].

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

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

The helideck structure is considered as first category element.

2  Materials and testing

2.1  Design temperature

2.1.1  For the purpose of steel grade requirements stated in [2.2] and [2.3], the design temperature of structural elements is to be calculated as required in Pt B, Ch 2, Sec 2, [6].

2.2  Offshore areas

2.2.1  General
The steel grade of elements belonging to offshore areas, as defined in [1.1.1], is to be determined in accordance with the requirements of Pt B, Ch 3, Sec 2.

2.2.2  Secondary category elements
The steel grades of structural elements categorized as secondary category are to comply with the most stringent between Pt B, Ch 3, Sec 2 of the present Rules and Pt B, Ch 4, Sec 1 of the Ship Rules.
2.3 Ship areas

2.3.1 The steel grade of elements belonging to ship areas as defined in [1.1.1], is to be chosen in accordance with Pt B, Ch 4, Sec 1 of the Ship Rules.

2.4 Steels with specified through thickness properties

2.4.1 The steels with specified through thickness properties are to comply with the requirements in Pt B, Ch 3, Sec 2, [4]

2.5 Inspection and checks

2.5.1 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.

2.5.2 Inspection of ship areas

For parts of the structure defined as ship areas, the requirements given in Pt B, Ch 11 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.

2.5.3 Inspection of offshore areas

For parts of the structure defined as offshore areas, reference is to be made to NR426, 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.

3 Structural principles

3.1 Accessibility for inspection during service

3.1.1 Principle

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

3.1.2 Underwater parts

When the additional class notation INWATERsurvey is granted to the units, special constructional features are to be provided as defined in Pt A, Ch 2, Sec 8, [2.2].

For underwater parts, marking and arrangements to facilitate inspections are to be provided. Marking is to 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.

3.1.3 Means of access

Each space within the unit is to be provided with permanent means of access in accordance with Pt B, Ch 3, Sec 1, [4].

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.

Inaccessible areas are to be clearly identified on structural drawings. The number of inaccessible areas is to be limited. The Society reserves the right to establish additional requirements related to corrosion protection of these areas. Special attention is to be paid to fatigue strength.

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.

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

3.2 General construction

3.2.1 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.
Figure 1: Typical arrangement with longitudinal bulkhead in centre line

Figure 2: Typical arrangement with two longitudinal bulkheads

3.2.2 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.

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.

3.2.3 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.

3.2.4 Docking brackets

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

3.2.5 Bilge keel

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

3.2.6 Sniped ends

As a rule, sniped ends of primary and secondary stiffeners are to be less than 30 degrees as indicated on Fig 4.

3.3 Plating

3.3.1 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.

3.4 Ordinary stiffeners

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

3.5 Primary supporting members

3.5.1 General

In the cargo area, the primary structure is composed of transverse web frames, stringers, buttress, deck girders, cross-ties, etc.
3.5.2 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 arm length of brackets connecting primary supporting members, as shown in Fig 3, is not to be less than the web depth of the member, and need not be taken greater than 1.5 times the web depth.

End brackets are generally to be soft-toed.

b) The net thickness of the end bracket web is generally to be not less than that of the adjoining primary supporting member web 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, excluding face plate where it is sniped, is not less than that of the primary supporting member at mid-span.

d) The net cross-sectional area $A_{f}$, in cm², of bracket face plates is to be such that:

$$A_{f} \geq \frac{\ell_{b} \cdot t_{b}}{K_{31} / K_{35} / K_{30} / K_{B0} / K_{52} / K_{33} / K_{6D} / K_{6D}}$$

where:

- $\ell_{b}$ : Length of the bracket edge, in m (see Fig 3).
  - For curved brackets, the length of the bracket edge may be taken as the length of the tangent at the midpoint of the edge
- $t_{b}$ : Minimum net bracket web thickness, in mm:

$$t_{b} \geq (2 + 0.2 \sqrt{w}) \frac{R_{y, S}}{R_{y, B}}$$

with:

- $w$ : Net required section modulus of the primary supporting member, in cm³.
- $R_{y, S}$ : Minimum yield stress, in N/mm², of the stiffener material.
- $R_{y, B}$ : Minimum yield stress, in N/mm², of the bracket material.

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 breadth 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

In general, full penetration welds should be applied as shown on the example of bracket with symmetrical face plate indicated in Fig 4 and Fig 5.
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
- the net sectional area, in cm², of web stiffeners is to be not less than $16.5 \ell$, where $\ell$ 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.

For a ring system, where the end bracket is integral with the web of the members and the face plate is welded continuously onto the edge of the members and the bracket, the full area of the larger face plate is to be maintained close to the mid-point of the bracket and gradually tapered to the smaller face plate. Butts in face plates are to be kept well clear of the bracket toes.

Where a wide face plate abuts a narrower one, the taper is not to be greater than 1 to 4.

The bracket toes are not to land on unstiffened plating. The toe height is not to be greater than the thickness of the bracket toe, but need not be less than 15 mm. In general, the end brackets of primary supporting members are to be soft-toed. Where primary supporting members are constructed of steel having a strength higher than the strength of the bracket steel, particular attention is to be paid to the design of the end bracket toes in order to minimise stress concentrations.

Where a face plate is welded onto, or adjacent to, the edge of the end bracket (see Fig 6), the face plate is to be snipped and tapered at an angle not greater than 30°.

g) In addition to the above requirements, the end brackets are to comply with the applicable requirements given in [7].

3.5.3 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:

- $p_S$, $p_W$: Still water and wave pressure, respectively, in kN/m², acting on the ordinary stiffener, defined in Ch 1, Sec 5
- $\gamma_{S2}$, $\gamma_{W2}$: Partial safety factors, defined in Ch 1, Sec 7 for yielding check (general).
- $k_1$: 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 7)
  - $k_1 = 0.225$ for connections with a collar plate (see Fig 8)
  - $k_1 = 0.20$ for connections with one or two large collar plates (see Fig 9 and Fig 10)

![Figure 6: Bracket face plate adjacent to the edge](image)

Note: The details shown in this Figure are only used to illustrate items described in the text and are not intended to represent a design guidance or recommendations.
c) Net moment of inertia

The net moment of inertia, I, of the web stiffeners of primary supporting members is not to be less than the value obtained, in cm$^4$, from the following formula:

- for web stiffeners parallel to the flange of the primary supporting members (see Fig 11):
  \[ I = C^2 A \frac{ReH}{235} \]

- for web stiffeners normal to the flange of the primary supporting members (see Fig 12):
  \[ I = 11.4 s t_w (2.5 (\bar{\ell}^2 - 2s^2) \frac{ReH}{235} \]

where:

- $C$ : Slenderness coefficient to be taken as:
  - $C = 1.43$ for longitudinal web stiffeners including snipped stiffeners
  - $C = 0.72$ for other web stiffeners
- $\bar{\ell}$ : Length, in m, of the web stiffener
- $s$ : Spacing, in m, of web stiffeners
- $t_w$ : Web net thickness, in mm, of the primary supporting member
- $A$ : Net section area, in cm$^2$, of the web stiffener, including attached plate assuming effective breadth of 80% of stiffener spacing $s$
- $ReH$ : Minimum specified yield stress of the material of the web plate of primary supporting member.

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

\[ d = 0.38b \]

\[ d = 0.85b \left( \frac{t}{41} \right) \]

where:

- $b$ : Height, in m, of tripping brackets, shown in Fig 13
- $s$ : 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 13. Tripping brackets with a net thickness, in mm, less than 15 $L_b$ 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.
3.5.4 Strength checks of cross-ties analysed through a three dimensional finite element

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:

\[ \sigma \leq \sigma_C \gamma_R \gamma_m \]

where:
- \( \sigma \): 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]
- \( \sigma_C \): Critical stress, in N/mm², defined in item b)
- \( \gamma_R \): Resistance partial safety factor: \( \gamma_R = 1.02 \)
- \( \gamma_m \): Material partial safety factor: \( \gamma_m = 1.02 \)

b) The buckling capacity of cross-ties is to be carried out according to NI 615, Buckling Assessment of Plated Structures. Buckling criteria is to be in accordance with Ch 1, Sec 7, [5.7.3].

3.5.5 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 [3.5.2].

The bracket ends are to be in accordance with [3.5.2].

In general, full penetration welds should be applied as shown on the example of buttress arrangement (see Fig 14).

3.5.6 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.

4 Net scantling approach

4.1 Principle

4.1.1 Except when otherwise specified, 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).

4.2 Corrosion additions

4.2.1 The corrosion additions are to be calculated as defined in Pt B, Ch 4, Sec 2, [3], of the Ship Rules.

The net scantling plus the corrosion addition is equal to the gross thickness.

4.2.2 If the party applying for classification specifies values of corrosion additions greater than those defined in [4.2.1], these values are to be taken into account for calculations and stated in the Design Criteria Statement.

5 Thickness increments

5.1 General

5.1.1 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.

\[ t_{\text{net}} = t_{\text{gross}} - t_c \]

\[ t_{\text{gross}} = t_{\text{as-built}} - t_i \]

where:
- \( t_c \): Thickness increment
- \( t_k \): Corrosion addition as defined in [4.2]
- \( t_{\text{net}} \): Net thickness
- \( t_{\text{gross}} \): Gross thickness;

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

5.1.2 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.

5.2 Thickness increment values

5.2.1 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 zero.
5.2.2 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, as follows:

a) When the Owner specifies its own thickness increments, it is to be notified to the Society where thickness increments are provided. Thickness increments are to be stated in the Design Criteria Statement.

b) When the Owner does not provide its own thickness increments, the values to be considered are defined in Tab 2.

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

Note 1: The additional notation STI, as defined in Pt A, Ch 1, Sec 2, [8.4.2], is strongly recommended for units covered by the present Chapter.

### Table 2: Thickness increments

<table>
<thead>
<tr>
<th>Structural element</th>
<th>Thickness increment, in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength deck</td>
<td>1</td>
</tr>
<tr>
<td>Bottom</td>
<td>1</td>
</tr>
<tr>
<td>Side shell above the maximum draught at site</td>
<td>1</td>
</tr>
<tr>
<td>Side shell below the minimum draught at site</td>
<td>1</td>
</tr>
<tr>
<td>Splash zone</td>
<td>5</td>
</tr>
<tr>
<td>Inner skin</td>
<td>1</td>
</tr>
<tr>
<td>Upper strake of longitudinal bulkhead</td>
<td>1</td>
</tr>
<tr>
<td>Lowest side stringer</td>
<td>1</td>
</tr>
</tbody>
</table>

6 Bulkhead structure

6.1 General

6.1.1 The requirements of the present Article [6] 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 14).

6.1.2 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.

6.1.3 Watertight bulkheads of trunks, tunnels

The requirements for watertight bulkheads of trunks and tunnels are given in Pt B, Ch 4, Sec 7, [1.3] of the Ship Rules.

6.1.4 Openings in watertight bulkheads

The requirements for openings in watertight bulkheads are given in Pt B, Ch 4, Sec 7, [1.4] of the Ship Rules.

6.1.5 Watertight doors

The requirements for watertight doors are given in Pt B, Ch 4, Sec 7, [1.5] of the Ship Rules.

6.2 Plane bulkheads

6.2.1 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.

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

6.2.3 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.

6.3 Swash bulkheads

6.3.1 General

The present [6.3] applies to transverse and longitudinal swash bulkheads whose main purpose is to reduce the liquid motions in partly filled tanks.

6.3.2 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 3.

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

6.4.1 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 3 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.

7 Bottom, side and deck structure

7.1 General

7.1.1 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.

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

7.2 Particular requirements for the side structure

7.2.1 Riser attachment

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

8 Reinforcements in way of supporting structures for hull attachments

8.1 Local arrangement

8.1.1 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 15.
9.3.4 Throat thickness of fillet welds for transverse web frames and horizontal stringers on transverse bulkheads are to be reinforced as shown in Fig 16 and Fig 17.

As a rule, full penetration welds are to be applied as shown in Fig 16 and Fig 17. The length of full penetration welds is not to be less than the greater of the following values:

a) length of the area where the tension stress normal to welds is above 0.3 times the tensile strength of the filler metal

b) 400 mm.

The tension stress and shear stress required in a) and b) are to be calculated based on the provisions of Ch 1, Sec 7, using a fine mesh finite element model. The size of elements is not to be above 100 mm x 100 mm. Values of stresses calculated at element centroid are to be used.

The length of areas defined in a) and b) is to include an entire number of 100 mm x 100 mm elements.

9.3.5 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  Application
Hydrodynamic analysis is to be performed for both site conditions and towing/transit phases, taking into account the probability levels defined in [1.1.3].

The target of hydrodynamic analysis is to assess design values and distributions of parameters related to wave loading, defined in [1.1.2].

Direct calculations are to be carried out. Hydrodynamic calculations may be calibrated based on model tests.

1.1.2  Parameters related to wave loading
The hydrodynamic analysis is to result in the following parameters specified with their distribution over the length of the unit:

- wave induced vertical bending moment
- wave induced horizontal bending moment
- wave induced vertical shear force
- local accelerations in three directions for upright and inclined conditions
- relative wave elevation in upright condition.

The hydrodynamic analysis is also to result in the motions and global accelerations at the floating unit centre of gravity:

- surge acceleration
- sway acceleration
- heave acceleration
- yaw acceleration
- roll amplitude and acceleration
- pitch amplitude and acceleration.

1.1.3  Return period of considered environment
The parameters defined in [1.1.2] are to correspond to a probability level of:

- once in 100 years (typically referred to by a probability level of $10^{-8.7}$) for the unit on site
- once in 10 years (typically referred to by a probability level of $10^{-7.7}$) for the unit in transit conditions, except when otherwise specified by the party applying for Classification (see Ch 1, Sec 1, [1.10.3]).
- $10^{-5.9}$, when requested for deterministic fatigue analysis, see Ch 1, Sec 7, [6.4]

For the inspection cases the environmental data may be taken into account at a lower return period.

1.1.4  Documents to be submitted
List of documents to be submitted is given in Ch 1, Sec 1, [6.1.1], item b).

1.2  Hydrodynamic analysis

1.2.1  Software
Assessment by direct calculation is to be carried out using a recognized software, generally using three dimensional potential flow based on diffraction radiation theory. The software is to be documented.

2  Environmental data for hydrodynamic analysis

2.1  General

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

2.2  Nature of environmental data

2.2.1  General
Two types of environmental data may be available:

- long-term data: wave description over a long period of time
- short-term data: wave description of extreme sea states.

2.2.2  Long-term data
Two types of long-term environmental data may be accepted:

a) Scatter diagrams
The sea state statistic data are generally provided under the form of a “scatter diagram” (table including significant wave height, wave period and number of occurrences). The reference duration on which the scatter diagram is built is to be indicated.

In order to ensure a good accuracy of results, classes of wave height and wave periods are not to be too coarse. Typically, intervals of 1 meter in significant wave height and 1 second in wave zero-up crossing period are to be used.

b) Hindcast data
Hindcast data consist of a time history of sea states (wave spectrum parameters, wave height, wave period, wave direction...), and eventually wind and current.

2.2.3  Short-term data
Short-term data consist of information about extreme environmental conditions, given by metocean specialist. They can be presented under extreme wave height and most probable associated period or contours wave height/wave period. Information on sea state duration is to be provided.
2.2.4 Combination of wave components
In the case of more than one wave component in environmental data, information about the combinations of different wave components (joint probabilities) is to be provided. When no information is available from metocean specification, the combinations defined in NR493, Classification of Mooring Systems for Permanent Offshore Units, are to be used.

When relevant, and particularly in cyclonic areas, information is to encompass seasonal extremes.

2.3 Environmental data to be submitted

2.3.1 Description of on-site environment
For hydrodynamic analysis, the following environmental data are to be submitted to the Society:
- general description of environmental conditions
- description of wave spectral content: for each component, wave spectrum with the specification of its characteristic parameters, directional spreading if any, and prevailing directions
- long-term data as defined in [2.2.2]. A minimum of 10-year data is to be used to derive properly 100 years responses. Information of sea state duration is to be provided
- short-term data as defined in [2.2.3]. Extreme values are to be given at least for a return period of 100 years
- restrictions of relative headings between the different components, if any
- information regarding combination of wave components as required in [2.2.4], when available.

2.3.2 Description of transit environment
A description of routes used for transit is to be submitted to the Society. In addition, for each geographic sector on which wave description is defined, the following items are to be submitted:
- time spent in each sector
- description of wave spectral content: for each component, wave spectrum with the specification of its characteristic parameters, directional spreading if any, and prevailing directions
- restrictions of relative headings between the different components, if any
- short-term data as defined in [2.2.3]. Extreme values are to be given at least for a return period consistent with [1.1.3]
- when available, long-term data as defined in [2.2.2]. The amount of data is to be at the satisfaction of the Society.

3 Design conditions

3.1 Loading conditions
3.1.1 Loading conditions used for hydrodynamic analysis are to be selected from those specified in the loading manual.

If the party applying for Classification specifies additional loading conditions, these conditions are to be taken into account. All parameters required by the Rules for the definition of these conditions are to be specified and stated in the Design Criteria Statement.

3.1.2 As a minimum, the following loading conditions are to be considered:
- on-site condition at design maximum draught, as defined in Ch 1, Sec 1, [3.2.11]
- on-site condition at design minimum draught, as defined in Ch 1, Sec 1, [3.2.11]
- on-site condition in still water giving maximum shear force
- at least one condition in towing/transit.

The selection of draughts corresponding to each loading condition is to be at the satisfaction of the Society.

3.2 Advance speed

3.2.1 Hydrodynamic analysis for on-site conditions are to be performed using an advance speed equal to zero.

3.2.2 Hydrodynamic analysis for towing/transit is to take into account both of the following cases:
- advance speed equal to zero
- advance speed as specified by the party applying for Classification.

4 Modelling principles

4.1 Hydrodynamic mesh

4.1.1 The wetted surface of the unit is to be modelled by elements having a size consistent with wave parameters (wave length and wave amplitude in particular). Mesh dimension of 2 meters is generally recommended. The model is to take into account the effects of appendices if any, and unit trim.

4.2 Mass distribution

4.2.1 Information regarding mass distribution along all axes and in particular gyration radius along longitudinal axis is to be submitted for each loading condition. Effects of free surface moment are to be taken into account and duly justified.

4.3 Connection with other structures

4.3.1 The society may request to take into account the connection of the floating unit with the seabed or other structures (risers, mooring...).

4.4 Water depth

4.4.1 Water depth is to be taken as indicated in the environmental data.
5 Floating unit responses

5.1 Results

5.1.1 The hydrodynamic analysis is to provide the following results for all loading conditions defined in [3.1]:

- floating unit natural periods, and
- for all parameters defined in [1.1.2]:
  - Response Amplitude Operators (RAOs) [3.1]
  - floating unit extreme values (single amplitude) at probability level defined in [1.1.3].

5.1.2 For all loading conditions, diagrams representing the variations of all parameters defined in [1.1.2] over the length of the floating unit and for various headings are to be submitted to the Society for review.

5.2 Response Amplitude Operators

5.2.1 General
RAOs (Response Amplitude Operators) of all parameters defined in [1.1.2] are to be calculated for each degree of freedom.

5.2.2 Wave headings
RAOs are to be calculated:
- for different headings including pure head, following and pure beam seas. RAOs are to be presented over all incidences
- with a step in headings not exceeding 15°, generally; the step is not to be less than 5° if directional spreading is used.

5.2.3 Wave frequencies
RAOs are to be calculated:
- for wave circular frequencies covering the anticipated sea states and spectra and typically from 0.1 rad/s to 2 rad/s
- with a step in wave circular frequencies not exceeding 0.05 rad/s. Refinements are to be performed around natural periods of the unit, in particular in roll.

5.2.4 Roll damping
Values and methodology taken into account for roll damping are to be duly justified.

5.3 Calculation of unit responses

5.3.1 Wave heading
Unit responses are to be calculated for all wave directions with a step not exceeding 15°. Pure head and following seas, and pure beam seas are to be considered.

The requirements of [5.3.2] and [5.3.3] are also to be considered.

5.3.2 Wave heading in transit/towing
In towing conditions, all wave headings (as defined in [5.3.1]) are to be taken at the same probability (no prevailing direction) unless otherwise specified as stated in Ch 1, Sec 1, [1.10].

5.3.3 Wave heading for Single Point Moored units
For site conditions of Single Point Moored units (SPM), all wave headings (as defined in [5.3.1]) are to be considered unless:

- restrictions of headings for operating conditions are available
- a heading analysis performed at the satisfaction of the Society demonstrates that several wave headings cannot occur in 100 years environments (including waves, current and wind).

5.3.4 Directional spreading on site
Directional spreading may be considered in accordance with metocean specification for site conditions.

5.3.5 Directional spreading in towing/transit
Directional spreading for towing/transit conditions may be considered in accordance with towing/transit metocean specification. As an alternative, the formulation given in [5.3.6] may be used.

5.3.6 Alternative formulation for directional spreading in towing/transit
The wave energy density function can be written as:

\[ S(\omega, \theta) = D(\theta) \cdot s(\omega) \]

where:

- \( D(\theta) \) : Directional spreading function, characterizing the directional distribution of the wave energy around a main direction \( \theta_m \); by default, this function is to be taken as:
  \[ D(\theta) = k \cos^2(\theta) \]
  with \( k \) satisfying:
  \[ \sum_{0° \leq \theta \leq 90°} D(\theta) = 1 \]
- \( s(\omega) \) : Wave energy spectrum.

5.3.7 Sensitivity analysis
During hydrodynamic analysis, sensitivity analyses are to be performed on the following items, if deemed relevant:

- wave parameters (wave spectrum parameter, direction...)
- wave periods:
  - based on wave height/wave period contours
  - performing a sensitivity study around the most probable wave period as defined by metocean specification. A range of at least \( \pm 15\% \) around the most probable peak period is to be considered
- other parameters (trim, loading of unit,...).

5.4 Design wave loads for structural analysis

5.4.1 The design values and distributions of the wave loads derived from extreme values obtained as per [5.1] are to be determined as defined in Ch 1, Sec 5, [3].
SECTION 5  DESIGN LOADS

Symbols

\[ \begin{align*}
L & : \text{Length, in m, as defined in Ch 1, Sec 1, [3.2.7]} \\
L_1 & : \text{L, but to be taken not greater than 200 m} \\
B & : \text{Breadth, in m, as defined in Pt B, Ch 1, Sec 2, [3.1] of the Ship Rules} \\
D & : \text{Depth, in m, as defined in Pt B, Ch 1, Sec 2, [3.5] of the Ship Rules} \\
T & : \text{Maximum draught, in m, as defined in:} \\
& \quad \text{Ch 1, Sec 1, [3.2.11] for site condition} \\
& \quad \text{Ch 1, Sec 1, [3.2.12] for transit condition} \\
T_1 & : \text{Draught associated to the loading condition considered} \\
n & : \text{Navigation coefficient, defined in [3.2]} \\
C_B & : \text{Total block coefficient, defined in [3.2]} \\
\Delta & : \text{Moulded displacement, in tonnes, at draught T,} \\
& \text{in sea water (density } \rho = 1,025 \text{ t/m}^3) \\
C & : \text{Wave parameter, to be taken equal to:} \\
& \quad C = (118 - 0.36L) \frac{L}{100} \text{ for } 65m \leq L < 90m \\
& \quad C = 10.75 \left( \frac{300 - L}{100} \right)^{1.5} \text{ for } 90m \leq L < 300m \\
& \quad C = 10.75 \text{ for } 300m \leq L \leq 350m \\
& \quad C = 10.75 - \frac{(L - 350)}{150} \text{ for } 350 < L \leq 500m \\
h_W & : \text{Wave parameter, in m, equal to:} \\
& \quad h_W = 11.44 - \frac{L - 250}{110} \text{ for } L < 350m \\
& \quad h_W = \frac{200}{L} \text{ for } 350 \leq L \leq 500m \\
\alpha_R, T_R, A_R & : \text{Roll acceleration, in rad/s}^2, \text{ role period, in s, and} \\
& \text{roll amplitude, in rad, defined in [3.4.5]} \\
\alpha_P, T_P, A_P & : \text{Pitch acceleration, in rad/s}^2, \text{ pitch period, in s,} \\
& \text{and pitch amplitude, in rad, defined in [3.4.6]} \\
\alpha_Y & : \text{Yaw acceleration, in rad/s}^2, \text{ defined in [3.4.7]} \\
g & : \text{Gravity acceleration, in m/s}^2, \text{ taken equal to 9.81} \\
V_S & : \text{Maximum ahead speed in transit, in knots.}
\end{align*} \]

1 General

1.1 Principles

1.1.1 Application

The design loads are to be determined in accordance with the present Section, considering the relevant loading conditions and associated loads as listed in Ch 1, Sec 1, [1.5.4].

1.1.2 Site conditions

The design loads for site conditions are to be determined as stated in the present Section, taking into account the results of hydrodynamic analysis (see Ch 1, Sec 4, [5]). Two situations may be considered:

- when a navigation notation completes the site notation of the unit, the rule values of wave loads for this navigation notation are to be superimposed with the values obtained from hydrodynamic analysis, as defined in [3.2]
- when no navigation notation is granted to the unit for on-site conditions, the wave loads obtained from hydrodynamic analysis are to be superimposed with the rule values calculated for sheltered area, as defined in [3.2].

1.1.3 Transit conditions

The design loads for transit conditions are to be determined as stated in the present Section, taking into account the results of hydrodynamic analysis (see Ch 1, Sec 4, [5] and Ch 1, Sec 1, [1.10.3]). Two situations may be considered:

- when a navigation notation completes the transit notation of the unit, the rule values of wave loads for this navigation notation are to be superimposed with the values obtained from hydrodynamic analysis, as defined in [3.2]
- when no navigation notation is granted to the unit for transit conditions, the wave loads obtained from hydrodynamic analysis are to be used, as defined in [3.2].

1.2 Definitions

1.2.1 The definition of the following terms are given 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 Hull girder loads
The wave and dynamic hull girder loads are 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 [5] and [6], according to the requirements in Ch 1, Sec 7.

1.3.2 Load cases
The local loads defined in [5] and [6] for the transit and site conditions are to be calculated in each of the mutually exclusive load cases described in [4].

1.3.3 Unit motions and global accelerations
The wave local loads are to be calculated on the basis of the reference values of unit motions and global accelerations specified in [3.4].

1.3.4 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 unit motions and global accelerations,

are specified in [5] and [6].

1.3.5 Flooding conditions
The still water and wave pressures in flooding conditions are specified in [6.6].

1.3.6 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 Ch 1, Sec 9, [3]).

Accidental loading cases may be required for the transit and site phases.

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

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. The return period of such environmental loads is generally taken as 1 year.

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 platting according to Ch 1, Sec 7, [2] and ordinary stiffeners according to Ch 1, Sec 7, [3].

b) Load model
1) 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.

2) 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 counter-action from the ship interior. This calculation is to be done considering the maximum draught
- 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.

Note 1: the external wave pressure in case “b” is to be taken equal to 0.

In the absence of more precise information, the unit minimum draught at site, in m, is to be obtained from the following formula:

\[ T_{\text{mini}} = 2 + 0.02 L \]

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 10, Sec 2, [2] and Pt B, Ch 10, Sec 2, [3] of the Ship Rules for the service notation oil tanker ESP.

In addition the requirements given from [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 transit
- in wet conditions at site (including loads from mooring system in case of pre-tension in lines).

The interface management quality plan for co-ordination between shipyard and topsides fabrication yard and the procedures for transfer of data for update of stability manual are 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 are to 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 four categories:
- maximum / minimum conditions at site
- intermediate conditions at site
- inspection conditions at site
- maximum / minimum conditions during transit.

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 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 Transit condition to intended site
The loading cases for the transit between shipyard and the intended site must be available in the loading manual. 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 transit conditions are 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.

2.2 Hull girder still water loads

2.2.1 Transit and site loads
The hull girder still water loads as per [2.2.2] and [2.2.3] have to be defined for both transit and on-site conditions. For this purpose, two distinct sets of still water bending moments and shear forces are to be specified.

2.2.2 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.

2.2.3 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 10, 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 to the procedures indicated in the Ship Rules as referenced above.
3 Wave loads

3.1 Transit and site conditions

3.1.1 Wave loads defined in the present Article are to be processed for both transit and on-site conditions. For this purpose, two distinct sets of design wave loads are to be considered.

3.2 Determination of the design wave loads

3.2.1 Definitions

The following terms are used to describe the wave loads:
- Wave load values: wave load parameters constant along the length of the unit (absolute unit motions and accelerations at the centre of gravity of the unit).
- Wave load distributions: wave load parameters varying along the length of the unit (e.g. hull girder wave loads, relative wave elevation).

3.2.2 Design values and distributions for ship areas

For ship areas, the design values and distributions of wave loads are the maximum between:
- Hydrodynamic values and distributions defined in [3.2.4]
- Minimum values and distributions (for site condition only) defined in [3.2.7]
- Rule values and distributions, if a navigation notation is granted, as defined in [3.2.5]

The design wave loads are to be entered in the Design Criteria Statement.

The following design values are to be provided:
- Absolute motions and global accelerations at the centre of gravity of the unit:
  - surge acceleration
  - sway acceleration
  - heave acceleration
  - yaw acceleration
  - roll amplitude and acceleration
  - pitch amplitude and acceleration

Note 1: Amplitude and acceleration in roll and pitch cannot be dissociate from each other. The rule values are to be adopted unless that hydrodynamic value of either the amplitude or the acceleration are found higher. In this case, both the amplitude and acceleration are to be adopted based on hydrodynamic values.

The following design distributions are to be provided:
- Hull girder loads defined in [3.3] and detailed below:
  - Vertical wave bending moment - Hoggining
  - Vertical wave bending moment - Sagging
  - Horizontal wave bending moment
  - Vertical wave shear force - positive
  - Vertical wave shear force - negative.
- Relative wave elevation, defined in [3.5.1]
- Local accelerations in three directions for upright and inclined conditions, defined in [3.6].

3.2.3 Design values and distributions for offshore areas

For offshore areas, the design values and distributions are to be based on hydrodynamic analysis as defined in [3.2.4].

3.2.4 Hydrodynamic values and distributions

Hydrodynamic values and distributions of the wave loads are based on the results of the hydrodynamic analysis specified in Ch 1, Sec 4.

At preliminary stage, if the hydrodynamic analysis is not available, the Society may accept hydrodynamic values and distributions determined by the Designer, if duly justified.

3.2.5 Rule values and distributions

When a navigation notation as defined in Ch 1, Sec 1, [1.2.3] is granted to complete the site or the transit notation, rule values and distributions are to be calculated based on the formulas defined in the present Section and with the corresponding navigation coefficient as given in Tab 1.

Note 1: It is reminded that the determination of fore and aft parts of the unit is established on a case-by-case basis, depending of the main wave heading (see Ch 1, Sec 1, [3.2.8]).

### Table 1: Navigation coefficient n

<table>
<thead>
<tr>
<th>Navigation notation</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrestricted navigation</td>
<td>1,00</td>
</tr>
<tr>
<td>Summer zone</td>
<td>0,90</td>
</tr>
<tr>
<td>Tropical zone</td>
<td>0,80</td>
</tr>
<tr>
<td>Coastal area</td>
<td>0,80</td>
</tr>
<tr>
<td>Sheltered area</td>
<td>0,65</td>
</tr>
</tbody>
</table>

3.2.6 Selection of the navigation notation

When hydrodynamic values and distributions are significantly above rule values and distributions, the Society reserves the right to change the navigation notation with a more severe one.

3.2.7 Minimum values and distributions

Minimum values and distributions are rule values calculated for sheltered area according to Tab 1.

3.2.8 Factors of environment

The following factors of environment are to be defined with their distribution along the length of the unit:

\[ f_{VBM} = \frac{M_{VBM, hyd}}{M_{VBM, S}} \]

\[ f_{RWE} = \frac{RWE}{h_r} \]
where:

- \( MWV_{Hyd} \): Hydrodynamic distribution of the vertical wave bending moment obtained according to [3.2.4].
- \( MWV_{SS} \): Rule distribution of vertical wave bending moment in sagging defined in [3.3.1] and calculated for unrestricted navigation as per Tab 1.
- \( RWE \): Hydrodynamic distribution of the relative wave elevation obtained according to [3.2.4].
- \( h_1 \): Rule distribution of the relative wave elevation defined in [3.5] and calculated for unrestricted navigation as per Tab 1.

### 3.3 Hull girder wave loads

#### 3.3.1 Vertical wave bending moment

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

- **Hogging conditions:**
  \[
  MWV,H = 190 \, F_M \, n \, C \, L^2 \, B \, CB \, 10^{-3}
  \]

- **Sagging conditions:**
  \[
  MWV,S = -110 \, F_M \, n \, C \, L^2 \, B \, (CB + 0.7) \, 10^{-3}
  \]

where:

- \( F_M \): Distribution factor defined in Tab 2 and Fig 1.

#### 3.3.2 Horizontal wave bending moment

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

\[
M_{HW} = 0.42 \, F_M \, n \, H \, L^2 \, T \, CB
\]

where:

- \( F_M \): Distribution factor defined in Tab 2 and Fig 1.

#### 3.3.3 Vertical wave shear force

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

\[
Q_{WV} = 30 \, F_Q \, n \, C \, L \, B \, (CB + 0.7) \, 10^{-2}
\]

where:

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

### Table 2: Distribution factor \( F_M \)

<table>
<thead>
<tr>
<th>Hull transverse section location</th>
<th>Distribution factor ( F_M )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0 \leq x &lt; 0.4 , L )</td>
<td>2.5 ( \frac{x^2}{L} )</td>
</tr>
<tr>
<td>( 0.4 , L \leq x &lt; 0.65 , L )</td>
<td>1</td>
</tr>
<tr>
<td>( 0.65 , L \leq x &lt; )</td>
<td>2.86 ( \left(1 - \frac{x}{L}\right) )</td>
</tr>
</tbody>
</table>

### Figure 1: Distribution factor \( F_M \)

### Table 3: Distribution factor \( F_Q \)

<table>
<thead>
<tr>
<th>Hull transverse section location</th>
<th>Positive wave shear force</th>
<th>Negative wave shear force</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0 \leq x &lt; 0.2 , L )</td>
<td>( 4.6 A \frac{x}{L} )</td>
<td>(-4.6 \frac{x}{L} )</td>
</tr>
<tr>
<td>( 0.2 , L \leq x \leq 0.3 , L)</td>
<td>0.92 ( A )</td>
<td>(-0.92 )</td>
</tr>
<tr>
<td>( 0.3 , L &lt; x &lt; 0.4 , L )</td>
<td>((9.2A - 7)\left(0.4 - \frac{x}{L}\right) + 0.7)</td>
<td>(-2.2\left(0.4 - \frac{x}{L}\right) - 0.7)</td>
</tr>
<tr>
<td>( 0.4 , L \leq x \leq 0.6 , L)</td>
<td>0.7</td>
<td>(-0.7 )</td>
</tr>
<tr>
<td>( 0.6 , L &lt; x &lt; 0.7 , L )</td>
<td>(3\left(\frac{x}{L} - 0.6\right) + 0.7)</td>
<td>(-10A - 7\left(\frac{x}{L} - 0.6\right) - 0.7)</td>
</tr>
<tr>
<td>( 0.7 , L \leq x \leq 0.85 , L)</td>
<td>1</td>
<td>(-A )</td>
</tr>
<tr>
<td>( 0.85 , L &lt; x \leq L )</td>
<td>(6.67\left(1 - \frac{x}{L}\right))</td>
<td>(-6.67A\left(1 - \frac{x}{L}\right))</td>
</tr>
</tbody>
</table>

**Note 1:**

\[
A = \frac{190CB}{110(C_B + 0.7)}
\]
3.4 Unit absolute motions and global accelerations

3.4.1 General
Rule values of the unit absolute motions and global accelerations are to be determined according to [3.4.2] to [3.4.7] with the parameter aB obtained from the following formulae:

- For on-site conditions:
  \[ a_S = n \left( \frac{2.4}{L} + \frac{h_w}{L} \right) \]
- For transit conditions:
  \[ a_S = n \left( \frac{0.2V_S}{L} + \frac{h_w}{L} \right) \]

Unit motions and global accelerations are defined, with their signs, according to the reference co-ordinate system in Ch 1, Sec 1.

Unit motions and global accelerations are assumed to be periodic. The motion amplitudes, defined by the formulae in this Article, are half of the crest to through amplitudes.

3.4.2 Surge
The rule surge acceleration \( a_{SU} \), in m/s², is to be taken equal to 0,8n.

3.4.3 Sway
The rule sway period and acceleration are obtained from the formulae in Tab 4.

3.4.4 Heave
The rule heave acceleration is obtained, in m/s², from the following formula:

\[ a_H = a_B g \]

Table 4 : Sway period and acceleration

<table>
<thead>
<tr>
<th>Period ( T_{SW} ), in s</th>
<th>Acceleration ( a_{SW} ), in m/s²</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{0.8L}{1.22F + 1} )</td>
<td>0.775 ( a_B g )</td>
</tr>
</tbody>
</table>

Note 1:
F : Froude's number to be taken equal to:
- for on-site conditions: \( F = 1.968/L^{0.5} \)
- for transit conditions: \( F = 0.164 V_S/L^{0.5} \)

3.4.5 Roll
The rule roll amplitude, period and acceleration are obtained from the formulae in Tab 5.

The meaning of symbols in Tab 5 is as follows:

\[ E = 1.39 \frac{GM}{\delta} B \] to be taken not less than 1,0

GM : Vertical distance, in m, from the unit centre of gravity to the transverse metacentre, for the loading considered, to be taken from the loading manual or Trim and Stability Booklet. When GM is not known, the values given in Tab 6 may be accepted by the Society on a case-by-case basis.

\( \delta \) : Roll radius of gyration, in m, for the loading considered, to be taken from the loading manual or Trim and Stability Booklet. When \( \delta \) is not known, a value of 0,35 B may be accepted by the Society on a case-by-case basis.

Table 5 : Roll amplitude, period and acceleration

<table>
<thead>
<tr>
<th>Amplitude ( A_R ), in rad</th>
<th>Period ( T_R ), in s</th>
<th>Acceleration ( \alpha_R ), in rad/s²</th>
</tr>
</thead>
</table>

\[ a_B \sqrt{E} \]

without being taken greater than 0.35

\[ A_R \left( \frac{2\pi}{T_R} \right)^2 \]

3.4.6 Pitch
The rule pitch amplitude, period and acceleration are obtained from the formulae in Tab 7.

3.4.7 Yaw
The rule yaw acceleration is obtained, in rad/s², from the following formula:

\[ \alpha_Y = 1.58 \frac{a_B g}{L} \]

Table 6 : Values of GM

<table>
<thead>
<tr>
<th>Service notation</th>
<th>Full load</th>
<th>Ballast</th>
</tr>
</thead>
<tbody>
<tr>
<td>oil storage</td>
<td>0,12 B</td>
<td>heavy ballast: 0,18 B light ballast: 0,24 B</td>
</tr>
<tr>
<td>Other</td>
<td>0,07 B</td>
<td>0,18 B</td>
</tr>
</tbody>
</table>

Table 7 : Pitch amplitude, period and acceleration

<table>
<thead>
<tr>
<th>Amplitude ( A_P ), in rad</th>
<th>Period ( T_P ), in s</th>
<th>Acceleration ( \alpha_P ), in rad/s²</th>
</tr>
</thead>
</table>

\[ 0.328a_B \left( 1.32 - \frac{2b_w}{L} \right) \left( \frac{0.6}{C_k} \right)^{0.75} \]

\[ 0.575 \sqrt{E} \]

\[ A_P \left( \frac{2\pi}{T_P} \right)^2 \]

3.5 Relative wave elevation

3.5.1 Design relative wave elevation in upright condition
The design distribution of the relative wave elevation in upright condition, \( h_{1,DES} \), in m, is the greatest of:

- rule distribution \( h_1 \)
- hydrodynamic distribution RWE.
3.5.2 Rule relative wave elevation in upright ship condition

The rule distribution of the relative wave elevation in upright ship condition is obtained, at any hull transverse section, from the formulae in Tab 8.

Table 8 : Rule relative wave elevation in upright ship condition

<table>
<thead>
<tr>
<th>Location</th>
<th>Reference value ( h_1 ) (m) of relative wave elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x = 0 )</td>
<td>0,7 ( \left( \frac{4,35}{C_B} - 3,25 \right) h_{1,M} ) if ( C_B &lt; 0,875 )  ( h_{1,M} ) if ( C_B \geq 0,875 )</td>
</tr>
<tr>
<td>( 0 &lt; x &lt; 0,3 ) L</td>
<td>( h_{1,M} - \frac{h_{1,AE} - h_{1,ME} x}{0,3} )</td>
</tr>
<tr>
<td>( 0,3 ) L ( \leq x \leq 0,7 ) L</td>
<td>0,67 m C ( (C_B + 0,7) )</td>
</tr>
<tr>
<td>( 0,7 &lt; x &lt; L )</td>
<td>( h_{1,M} + \frac{h_{1,ME} - h_{1,AE}(x - 0,7)}{0,3} )</td>
</tr>
<tr>
<td>( x = L )</td>
<td>( \left( \frac{4,35}{C_B} - 3,25 \right) h_{1,M} )</td>
</tr>
</tbody>
</table>

Note 1:
- \( h_{1,AE} \) : Reference value \( h_1 \) calculated for \( x = 0 \)
- \( h_{1,ME} \) : Reference value \( h_1 \) calculated for \( x = 0,5 \) L
- \( h_{1,FE} \) : Reference value \( h_1 \) calculated for \( x = L \)

3.5.3 Design relative wave elevation in inclined ship condition

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

\[
h_2 = 0,5 h_{1,DES} + A_{R,DES} \frac{B_W}{2}
\]

where:
- \( h_{1,DES} \) : Design distribution of relative wave elevation in upright condition
- \( B_W \) : Moulded breadth, in m, measured at the waterline at draught \( T_1 \) at the hull transverse section considered
- \( A_{R,DES} \) : Design value of roll amplitude as defined in [3.2.2]

Note 1: As an alternative the value of \( h_2 \) directly calculated by hydrodynamic analysis may be specially considered by the Society.

3.6 Local accelerations

3.6.1 The design values of reference longitudinal, transverse and vertical accelerations at any point are obtained from the formulae given in Tab 9 for upright and inclined conditions and based on the design unit absolute motions and global accelerations.

Note 1: As an alternative the local accelerations directly calculated by hydrodynamic analysis may be specially considered by the Society, for example: offshore appurtenances and associated loads distribution at foundation.

Note 2: load cases “a”, “b”, “c” and “d” are defined in [4].

4 Load cases

4.1 Transit and site conditions

4.1.1 Load cases defined in the present Article are to be processed for both transit and on-site conditions.

4.2 General

4.2.1 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 10 and Tab 11. 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.

Table 9 : Reference values of the accelerations \( a_x \), \( a_y \) and \( a_z \)

<table>
<thead>
<tr>
<th>Direction</th>
<th>Upright condition</th>
<th>Inclined condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>X - Longitudinal ( a_{x1} ) and ( a_{x2} ) in m/s²</td>
<td>( a_{x1} = \sqrt{a_{x1}^2 + [A_{Kg} + \alpha_3(z - T_1)]^2} )</td>
<td>( a_{x2} = 0 )</td>
</tr>
<tr>
<td>Y - Transverse ( a_{y1} ) and ( a_{y2} ) in m/s²</td>
<td>( a_{y1} = 0 )</td>
<td>( a_{y2} = \sqrt{a_{y1}^2 + [A_{Kg} + \alpha_4(z - T_1)]^2 + \alpha_4^2 K_x U^2} )</td>
</tr>
<tr>
<td>Z - Vertical ( a_{z1} ) and ( a_{z2} ) in m/s²</td>
<td>( a_{z1} = \sqrt{a_{z1}^2 + \alpha_2^2 K_z L^2} )</td>
<td>( a_{z2} = \sqrt{0,25 a_{z1}^2 + \alpha_2^2 K_z L^2} )</td>
</tr>
</tbody>
</table>

Note 1:
\[
K_x = 1,2 \left( \frac{x}{L} \right)^2 - 1,1 \frac{x}{L} + 0,2 \quad \text{without being taken less than 0,018}
\]
### Table 10: Wave local loads in each load case

<table>
<thead>
<tr>
<th>Ship condition</th>
<th>Load case</th>
<th>Relative wave elevations</th>
<th>Reference accelerations $a_x, a_y, a_z$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$h_{1,DES}$</td>
<td>$a_{x1}; 0; a_{z1}$</td>
</tr>
<tr>
<td>Upright</td>
<td>a</td>
<td>1.0</td>
<td>no acceleration taken into account</td>
</tr>
<tr>
<td></td>
<td>b (1) (2)</td>
<td>0.5</td>
<td>$a_{x2}; 0; a_{z2}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$C_{FA} = 0.7$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$C_{FA} = 1.0$</td>
</tr>
<tr>
<td>Inclined</td>
<td>c + (3)</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c - (4)</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d + (3)</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d - (4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. For a surface unit moving with a positive heave motion:
   - $h_{1,DES}$ is positive
   - the reference acceleration $a_{x1}$ is towards the direction which maximise the
   - the reference acceleration $a_{z1}$ is directed towards the negative part of the Z axis.

Note 1: Reference accelerations $a_{x1}$ and $a_{z1}$ are to be combined in each direction when assessing the foundations of equipment and appurtenances.

2. For plating and ordinary stiffeners, refer to [1.3.7]

3. For surface unit rolling with a negative roll angle (portside down):
   - $h_2$ is positive for the points located in the positive part of the Y axis and is negative for the points located in the negative part of the Y axis
   - the reference acceleration $a_{y2}$ is directed towards the positive part of the Y axis
   - the reference 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 is directed towards the positive part of the Z axis for the points located in the negative part of the Y axis.

4. For surface unit rolling with a positive roll angle (portside up)

Note 2: Other combinations may be required by the Society on a case by case basis.

### Table 11: Wave hull girder loads in each load case

<table>
<thead>
<tr>
<th>Ship condition</th>
<th>Load case</th>
<th>Vertical bending moment $M_{NW}$</th>
<th>Vertical shear force $Q_{NW}$</th>
<th>Horizontal bending moment $M_{OH}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a_crest</td>
<td>1.0</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>a_trough</td>
<td>0.7</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Upright</td>
<td>b</td>
<td>0.4</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.25</td>
<td>0.25</td>
<td>0.7</td>
</tr>
<tr>
<td>Inclined</td>
<td>c</td>
<td>0.4</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>0.25</td>
<td>0.25</td>
<td></td>
</tr>
</tbody>
</table>

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].

---

**Figure 3:** Wave loads in load case $a_c$ crest

**Figure 4:** Wave loads in load case $a_t$ trough

**Figure 5:** Wave loads in load case $b$

**Figure 6:** Wave loads in load case $c+$
5 Sea pressures

5.1 Transit and site conditions

5.1.1 Sea pressures defined in the present Article are to be processed for both transit and on-site conditions. For this purpose, two distinct sets of sea pressures are to be calculated.

5.2 General

5.2.1 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.

5.3 Still water pressure

5.3.1 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.

5.4 Wave pressure in upright ship conditions

5.4.1 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 12. See also Fig 8, Fig 9 and Fig 10.

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. The distribution is obtained from the formulae given in Tab 13.

Table 12 : Wave pressure on sides and bottom in upright ship conditions (load cases “a” and “b”)

<table>
<thead>
<tr>
<th>Location</th>
<th>Crest</th>
<th>Trough</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom and sides below the Waterline (z \leq T_1)</td>
<td>(\frac{\rho g C_{W1} h_1 (z + T_1)}{T_1})</td>
<td>(\frac{\rho g C_{W1} h_1 (z + T_1)}{T_1}) without being taken less than (\rho g (z - T_1))</td>
</tr>
<tr>
<td>Sides above the Waterline (z &gt; T_1)</td>
<td>(\rho g (T_1 + C_{W1} h_1 - z)) without being taken, for case “a” only, less than (0,15\varphi_1\varphi_2 L)</td>
<td>0,0</td>
</tr>
</tbody>
</table>

Note 1:

\(C_{W1}\) : Combination factor, to be taken equal to:

- \(C_{W1} = 1,0\) for load case “a”
- \(C_{W1} = 0,5\) for load case “b”.

\(\varphi_1, \varphi_2\) : Coefficients defined in Tab 13
5.5 Wave pressure in inclined ship conditions

5.5.1 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 14. See also Fig 11 and Fig 12.

5.5.2 Pressure on exposed decks

The wave pressure on exposed decks is to be considered for load cases “a crest” and “b crest” only (see [5.4.2]).
6 Internal pressures

6.1 Transit and site conditions

6.1.1 Internal pressures defined in the present Article are to be processed for both transit and on-site conditions. For this purpose, two distinct sets of internal pressures are to be calculated.

6.2 Definitions

6.2.1 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 transit between yard and site, the density is to be 1,025 t/m³.

6.2.2 Sea water

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

6.2.3 Total acceleration vector

The total acceleration vector \( \mathbf{A}_T \) is the vector whose absolute values of X, Y and Z components are the longitudinal, transverse and vertical accelerations defined in Tab 15.

In inclined ship conditions:

\[
\begin{align*}
Y, Z & : \text{Normed vectors as defined in Fig 13} \\
\alpha_{TY2}, \alpha_{TZ2} & : \text{Total accelerations for inclined ship conditions defined in Tab 15.}
\end{align*}
\]

\[
\begin{align*}
\alpha_{TX1} & = \alpha_{TX1} \\
\alpha_{TY1} & = \alpha_{TY1} \\
\alpha_{TZ1} & = -\alpha_{TZ1} - g
\end{align*}
\]

\[
\begin{align*}
\alpha_{TX2} & = \alpha_{TX2} \\
\alpha_{TY2} & = 0.7C_{FA}\alpha_{Y2} \\
\alpha_{TZ2} & = -0.7C_{FA}\alpha_{Z2} - g
\end{align*}
\]

Note 1: \( C_{FA} \) : Combination factor given in Tab 10.

6.2.4 Highest point H of the tank in the direction of the total acceleration vector \( \mathbf{A}_T \)

The highest point H of the tank in the direction of the total acceleration vector \( \mathbf{A}_T \), defined in [6.2.3], is the point of the tank boundary whose projection on the direction forming the angle \( \Phi \) 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.

6.3 Internal pressures and forces

6.3.1 Internal still water pressure

The still water pressure to be used in combination with the inertial pressure in [6.3.2] is the greater of the values obtained, in kN/m², from the following formulae:

\[
p_S = \rho_L g (z_L - z)
\]

\[
p_S = \rho_L g (z_{TCP} - z) + 100 p_{PV}
\]

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:

\[
p_{PV} : \text{Setting pressure, in bar, of safety valves}
\]

\[
z_{TCP} : \text{Z co-ordinate, in m, of the highest point of the tank in the z direction}
\]

\[
z_L : \text{Z co-ordinate, in m, of the highest point of the liquid:}
\]

\[
z_L = z_{TCP} + 0.5 (z_{AP} - z_{TCP})
\]

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

Note 1: Specific overflow systems leading to higher internal pressure are to be considered on case-by-case basis.
6.3.2 Internal inertial pressure

The inertial pressure is obtained from the formulae in Tab 16 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 [6.3.1].

6.3.3 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, [2] of the Ship Rules.

6.4 Partly filled tanks

6.4.1 General

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

A calculation is to be submitted.

6.4.2 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.

6.5 Accommodation

6.5.1 Design pressure

The scantlings of the accommodation decks are calculated using a conventional still water and inertial pressure as defined in [6.5.2].

6.5.2 Still water and inertial pressures

The inertial pressures transmitted to the deck structures are obtained, in kN/m², as specified in Tab 17.

6.6 Flooding

6.6.1 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 18.
### Table 18: Flooding

<table>
<thead>
<tr>
<th></th>
<th>Still water pressure $p_{SF}$, in kN/m²</th>
<th>Inertial pressure $p_{WF}$, in kN/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p \cdot g \left( z_F - z \right)$ without being taken less than 0.4 g $d_0$</td>
<td>$p_{SF} = \rho g \left( z_F - z \right)$ without being taken less than 0.4 g $d_0$</td>
<td>$p_{WF} = 0.6 \rho g z_F + g \left( z_F - z \right)$</td>
</tr>
</tbody>
</table>

**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 $90 \leq L \leq 120$
  - $d_0 = 2.4$ for $L \geq 120$

### 6.7 Testing

#### 6.7.1 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.

#### 6.7.2 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.
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 transit phases covered by classification and on-site conditions.

1.1.3 The hull girder is to 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:
  \[ \sigma_i = \frac{M_{SW} + M_{WV}}{Z_A} \cdot 10^3 \]

- at bottom:
  \[ \sigma_i = \frac{M_{SW} + M_{WV}}{Z_{AB}} \cdot 10^3 \]

- at deck:
  \[ \sigma_i = \frac{M_{SW} + M_{WV}}{Z_{AD}} \cdot 10^3 \]

where:

- \( M_{SW} \) : Still water bending moment, in kN.m, as defined in Ch 1, Sec 5, [2.2]
- \( M_{WV} \) : Vertical wave bending moment, in kN.m:
  - in hogging conditions:
    \[ M_{WV} = M_{WV,H} \]
  - in sagging conditions:
    \[ M_{WV} = M_{WV,S} \]
- \( M_{WV,H} \) : Vertical wave bending moment, in kN.m, in hogging condition, at the hull transverse section considered, defined in Ch 1, Sec 5, [3.3]
- \( M_{WV,S} \) : Vertical wave bending moment, in kN.m, in sagging condition, at the hull transverse section considered, defined in Ch 1, Sec 5, [3.3]
- \( Z_A \) : 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 2,06x10⁵ 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:

\[ \sigma_i = \frac{E}{2,06 \cdot 10^5} \sigma_{IS} \]

where:

- \( \sigma_{IS} \) : 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 \( \sigma_i \) calculated according to [2.1.1] are in compliance with the following formula:

\[ \sigma_i \leq \sigma_{i,ALL} \]

where:

- \( \sigma_{i,ALL} \) : Allowable normal stress, in N/mm², obtained from the following formulae:
  - for \( \frac{X}{L} \leq 0.1 \)
    \[ \sigma_{i,ALL} = \frac{125}{k} \]
  - for \( 0.1 < \frac{X}{L} \leq 0.3 \)
    \[ \sigma_{i,ALL} = \frac{175}{k} - \frac{250}{k} \left( \frac{X}{L} - 1 \right) \]
  - for \( 0.3 \leq \frac{X}{L} \leq 0.7 \)
    \[ \sigma_{i,ALL} = \frac{175}{k} \]
  - for \( 0.7 < \frac{X}{L} \leq 0.9 \)
    \[ \sigma_{i,ALL} = \frac{175}{k} - \frac{250}{k} \left( \frac{X}{L} - 0.7 \right) \]
  - for \( \frac{X}{L} \geq 0.9 \)
    \[ \sigma_{i,ALL} = \frac{125}{k} \]
2.2.2 Shear stresses

It is to be checked that the shear stresses $\tau_1$ calculated according to [2.1.3] are in compliance with the following formula:

$$\tau_1 \leq \tau_{1,\text{ALL}}$$

where:

$\tau_{1,\text{ALL}}$ : Allowable shear stress, in N/mm$^2$:

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

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 m$^3$, from the following formulae:

$$Z_{R,\text{MIN}} = \frac{\eta_1 C L^2 B (C_B + 0.7) k \times 10^{-6}}{\sigma_{\text{ALL}}}$$

where:

$Z_{R,\text{MIN}}$ : Minimum section modulus taken as the maximum value between $Z_{R,\text{MIN}}$ calculated for transit condition and calculated for site condition.

Parameters $n_1$ and $C_B$ are to be taken accordingly:

$n_1$ : Coefficient defined as follows:

- when a navigation notation completes the transit or site notation of the unit, $n_1$ is to be taken as given in Tab 1
- when no navigation notation is granted to the unit for the transit or site condition, $n_1$ is to be taken equal to the value of factor of environment for vertical wave bending moment, $f_{VBM}$, as defined in Ch 1, Sec 5, [3.2], but not less than 0.80.

Where the total breadth $\Sigma b_S$ 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 $Z_{R,\text{MIN}}$ 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 m$^3$, from the following formula:

$$Z_k = \frac{M_{\text{MIN}} + M_{\text{MV}}}{k} \times 10^{-3}$$

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 8 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 m$^4$, from the following formula:

$$I_{YR} = \frac{3 Z'R_{,\text{MIN}} L}{10^{-2}}$$

where $Z'R_{,\text{MIN}}$ is the required midship section modulus $Z_{R,\text{MIN}}$ in m$^3$, 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):

$$V_{HB} = \frac{\sigma_{\text{IB}} - k\sigma_{\text{ALL}}}{\sigma_{\text{IB}} + \sigma_{\text{ID}}} z_D$$

- 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):

$$V_{HD} = \frac{\sigma_{\text{ID}} - k\sigma_{\text{ALL}}}{\sigma_{\text{IB}} + \sigma_{\text{ID}}} (N + V_D)$$

where:

$\sigma_{\text{IB}}, \sigma_{\text{ID}}$ : Normal stresses, in N/mm$^2$, 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, [3.3]

---

Table 1 : Navigation coefficient $n_1$

<table>
<thead>
<tr>
<th>Navigation notation</th>
<th>Navigation coefficient $n_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrestricted navigation</td>
<td>1,00</td>
</tr>
<tr>
<td>Summer zone</td>
<td>0,95</td>
</tr>
<tr>
<td>Tropical zone</td>
<td>0,90</td>
</tr>
<tr>
<td>Coastal area</td>
<td>0,90</td>
</tr>
<tr>
<td>Sheltered area</td>
<td>0,80</td>
</tr>
</tbody>
</table>

---
3 Ultimate strength check

3.1 General

3.1.1 The ultimate strength of the hull girder is to be checked for transit and on site conditions 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.

3.3 Hull girder loads

3.3.1 Bending moment

The bending moments in transit and on site conditions, in sagging and hogging, to be considered in the ultimate strength check of the hull girder, are to be obtained, in kN.m, from the following formula:

\[ M = \gamma_S M_{SW} + \gamma_W M_{WV} \]

Table 2: Partial safety factors

<table>
<thead>
<tr>
<th>Partial safety factor covering uncertainties on:</th>
<th>Symbol</th>
<th>On-site condition value</th>
<th>Transit condition value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Still water hull girder loads</td>
<td>(\gamma_S)</td>
<td>1,00</td>
<td>1,00</td>
</tr>
<tr>
<td>Wave induced hull girder loads</td>
<td>(\gamma_W)</td>
<td>1,25 (1)</td>
<td>1,10</td>
</tr>
<tr>
<td>Material</td>
<td>(\gamma_m)</td>
<td>1,02</td>
<td>1,02</td>
</tr>
<tr>
<td>Resistance</td>
<td>(\gamma_R)</td>
<td>1,10</td>
<td>1,03</td>
</tr>
</tbody>
</table>

(1) If the vertical wave bending moment \(M_{WV}\) considered is derived from hydrodynamic calculations with a 10 000 years return period, the partial safety factor \(\gamma_W\) may be reduced to 1,00.

In this case, the product \(\gamma_W \times M_{WV}\) defined above with 10 000 years RP is not to be less than 1.25 \(M_{WV}\) derived with 100 years RP.

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:

\[ \frac{M_U}{\gamma_S \gamma_m} \geq M \]

where:

\(M_U\) : Ultimate bending moment capacity of the hull transverse section, in kN.m, as defined in Pt B, Ch 6, Sec 3, [3.3] of the Ship Rules.
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, [2.2.2] for transit and site conditions

\( M_{SW,S} \) : Design still water bending moment, in kN.m, in sagging condition, at the hull transverse section considered, defined in Ch 1, Sec 5, [2.2.2] for transit and site conditions

\( M_{WW,H} \) : Vertical wave bending moment, in kN.m, in hogging condition, at the hull transverse section considered, defined in Ch 1, Sec 5, [3.3.1] for transit and site conditions

\( M_{WW,S} \) : Vertical wave bending moment, in kN.m, in sagging condition, at the hull transverse section considered, defined in Ch 1, Sec 5, [3.3.1] for transit and site conditions

\( M_{WH} \) : Horizontal wave bending moment, in kN.m, at the hull transverse section considered, defined in Ch 1, Sec 5, [3.3.2] for transit and site conditions

\( M_{SW,H_{\text{min}}} \) : Minimum still water bending moment, in kN.m, in hogging condition, at the hull transverse section considered without to be taken greater than \( 0.3M_{WW,S} \)

\( N \) : Z co-ordinate, in m, with respect to the reference co-ordinate system (defined in Ch 1, Sec 1, [3.3]) 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, [3.3]

\( I_N \) : 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

\( \ell \) : Span, in m, of ordinary stiffeners, measured between supporting members (see Pt B, Ch 4, Sec 3, [3.2] of the Ship Rules

\( \rho_S \) : Static pressure, in kN/m^2, as defined in Ch 1, Sec 5

\( \rho_w \) : 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

\( \eta \) : Buckling utilisation factor defined as the highest ratio between the applied loads and the corresponding ultimate capacity or buckling strength obtained for the different buckling modes.

1  General

1.1  Principle

1.1.1  Application

The requirements of the present Section cover the assessment of structural elements for the transit and site conditions of the unit, except when otherwise specified.

The hull scantlings are to be evaluated independently for transit and site conditions.

1.1.2  General reference

Plating, ordinary stiffeners and primary supporting members are to comply with the requirements of Pt B, Chapter 7 and Pt 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.

1.1.3  Net thickness

All thickness referred to in this Section are net, i.e. they do not include any margin for corrosion.

The applicable corrosion additions are those specified in Ch 1, Sec 3, [4.2].

1.1.4  Partial safety factors

The partial safety factors to be considered for the determination of the rule scantlings are specified in the present Section.

1.1.5  Slenderness requirement

Structural members are to comply with slenderness and proportion requirements of NI 615, Buckling Assessment of Plated Structures.
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.

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:
  \[ \sigma_{z1} = 0 \]
- for plating contributing to the hull girder longitudinal strength:
  \[ \sigma_{z1} = \gamma_{S1}\sigma_{S1} + \gamma_{W1}(C_{FW}\sigma_{FW1} + C_{FH}\sigma_{FH1}) \]

where:
\( \sigma_{S1}, \sigma_{FW1}, \sigma_{FH1} \): Hull girder normal stresses, in N/mm², defined in Tab 2.
\( C_{FW}, C_{FH} \): 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:

\[ \tau_{z1} = \gamma_{S1}\tau_{S1} + C_{FW}\gamma_{W1}\tau_{W1} \]

where:
\( C_{FW} \): Combination factor given in Tab 3
\( \tau_{S1}, \tau_{W1} \): 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.
\( \tau_{W1} \): 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.
\( \tau_{S1} \) and \( \tau_{W1} \) 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 NI 615, Buckling Assessment of Plated Structures. The compression and shear stresses to be taken into account for the checking criteria are to be calculated in accordance with [2.3.2] to [2.3.6].

### Table 1: Plating - Partial safety factors

<table>
<thead>
<tr>
<th>Partial safety factors covering uncertainties regarding:</th>
<th>Symbol</th>
<th>Strength check of plating subjected to lateral pressure</th>
<th>Testing check</th>
<th>Buckling check</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>General</td>
<td>Sloshing pressure</td>
<td>Watertight bulkhead plating (1)</td>
</tr>
<tr>
<td>Still water hull girder loads</td>
<td>( \gamma_{S1} )</td>
<td>1,00</td>
<td>0</td>
<td>1,00</td>
</tr>
<tr>
<td>Wave hull girder loads</td>
<td>( \gamma_{W1} )</td>
<td>1,07</td>
<td>0</td>
<td>1,07</td>
</tr>
<tr>
<td>Still water pressure</td>
<td>( \gamma_{S2} )</td>
<td>1,00</td>
<td>1,00</td>
<td>1,00</td>
</tr>
<tr>
<td>Wave pressure</td>
<td>( \gamma_{W2} )</td>
<td>1,07</td>
<td>1,05</td>
<td>1,07</td>
</tr>
<tr>
<td>Material</td>
<td>( \gamma_{m} )</td>
<td>1,02</td>
<td>1,02</td>
<td>1,02</td>
</tr>
<tr>
<td>Resistance</td>
<td>( \gamma_{r} )</td>
<td>1,02</td>
<td>1,10</td>
<td>1,02 (2)</td>
</tr>
</tbody>
</table>

(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, \( \gamma_{r} = 1,25 \)

**Note 1:** N.A. = not applicable.

### Table 2: Hull girder normal stresses

<table>
<thead>
<tr>
<th>Condition</th>
<th>( \sigma_{S1}, \text{in N/mm}^2 (1) )</th>
<th>( \sigma_{FW1}, \text{in N/mm}^2 (1) )</th>
<th>( \sigma_{FH1}, \text{in N/mm}^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \delta_{1}/M_{WWS} + \gamma_{S1}M_{WWS}/M_{WWS} \geq 1 )</td>
<td></td>
<td>( \frac{M_{WWS}}{I_{y}(z-N)} \times 10^{-3} )</td>
<td>( \frac{M_{WWS}}{I_{y}(z-N)} \times 10^{-3} )</td>
</tr>
<tr>
<td>( \delta_{1}/M_{WWS} + \gamma_{S1}M_{WWS}/M_{WWS} &lt; 1 )</td>
<td></td>
<td>( \frac{M_{WWS}}{I_{y}(z-N)} \times 10^{-3} )</td>
<td>( \frac{M_{WWS}}{I_{y}(z-N)} \times 10^{-3} )</td>
</tr>
</tbody>
</table>

(1) When the unit in still water is always in hogging condition, \( M_{WWS} \) is to be taken equal to 0.
Pt D, Ch 1, Sec 7

Table 3: Combination factor $C_{FV}$ and $C_{FH}$ for plating

<table>
<thead>
<tr>
<th>Load case</th>
<th>$C_{FV}$</th>
<th>$C_{FH}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;a&quot;</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>&quot;b&quot;</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>&quot;c&quot;</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>&quot;d&quot;</td>
<td>0.25</td>
<td>0.7</td>
</tr>
</tbody>
</table>

$\sigma_{X1}$ is to be taken as the maximum compression stress on the plate panel considered.

When the ship in still water is always in hogging condition, $\sigma_{X1}$ 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.

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:

$$\sigma = \frac{MS_{SW}I_y}{L_{x}} + \frac{MW_{V1}I_y}{L_{x}} - \frac{M_{WH}I_y}{L_{x}}$$

where:

- $MS_{SW}$: Bending moment, in N-mm², due to the still water load
- $MW_{V1}$: Bending moment, in N-mm², due to the wave load
- $M_{WH}$: Bending moment, in N-mm², due to the wave load
- $I_{x}$: Moment of inertia about the x-axis
- $L_{x}$: Length of the plate panel

$\sigma_{X1}$ is to be obtained, in N/mm², from the following formula, unless $\sigma_{X1}$ is evaluated by means of direct calculations (see [2.3.2]):

$$\sigma_{X1} = \frac{M_{SW}I_y}{L_{x}}$$

Table 4: Hull girder shear stresses

<table>
<thead>
<tr>
<th>Structural element</th>
<th>$\tau_{S1}$, $\tau_{W1}$ in N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom, inner bottom and decks (excluding possible longitudinal sloping plates)</td>
<td>0</td>
</tr>
<tr>
<td>Bilge, side, inner side and longitudinal bulkheads (including possible longitudinal sloping plates):</td>
<td>$\tau_{0}(0.5 + 2\frac{Z}{D})$</td>
</tr>
<tr>
<td>$0 \leq Z \leq 0.25 D$</td>
<td>$\tau_{0}$</td>
</tr>
<tr>
<td>$0.25 D &lt; Z \leq 0.75 D$</td>
<td>$\tau_{0}(2.5 - 2\frac{Z}{D})$</td>
</tr>
<tr>
<td>$0.75 D &lt; Z \leq D$</td>
<td>$\tau_{0}$</td>
</tr>
</tbody>
</table>

Note 1:

$$\tau_{0} = \frac{47}{k}\left[1 + \frac{6.3}{\sqrt{L_{x}}}\right] N/mm²$$

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 5.

With respect to the reference co-ordinate system defined in Ch 1, Sec 1, [3.3], the combined stresses in x and y direction are obtained, in N/mm², from the following formulae:

$$\sigma_{x} = \sigma_{S1} + \gamma_{S1}\sigma_{WL1} + \gamma_{V1}\sigma_{WL2}$$

$$\sigma_{y} = \gamma_{S2}\sigma_{WL1} + \gamma_{V2}\sigma_{WL2}$$

where:

- $\sigma_{S1}$: 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]
- $\sigma_{WL1}$: Compression normal stress in x direction, in N/mm², induced by the hull girder lateral loads
- $\sigma_{WL2}$: Compression normal stress in y direction, in N/mm², induced by the hull girder lateral loads

Table 5: Hull girder normal compression stresses for buckling check of plates

<table>
<thead>
<tr>
<th>Condition</th>
<th>$\sigma_{S1}$ in N/mm² (1)</th>
<th>$\sigma_{WL1}$ in N/mm²</th>
<th>$\sigma_{WL2}$ in N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>$z \geq N$</td>
<td>$\frac{M_{SW}}{L_{x}}(z - N)10^{-3}$</td>
<td>$\frac{M_{SW}}{L_{x}}(z - N)10^{-3}$</td>
<td>$\frac{M_{WH}}{L_{x}}(z - N)10^{-3}$</td>
</tr>
<tr>
<td>$z &lt; N$</td>
<td>$\frac{M_{SW}}{L_{x}}(z - N)10^{-3}$</td>
<td>$\frac{M_{WL1}}{L_{x}}(z - N)10^{-3}$</td>
<td>$\frac{M_{WL2}}{L_{x}}(z - N)10^{-3}$</td>
</tr>
</tbody>
</table>

Note:

(1) When the unit in still water is always in hogging condition, $\sigma_{S1}$ for $z \geq N$ is to be obtained, in N/mm², from the following formula, unless $\sigma_{S1}$ is evaluated by means of direct calculations (see [2.3.2]):

$$\sigma_{S1} = \frac{M_{SW}I_y}{L_{x}}(z - N)10^{-3}$$
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 5.

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:

- \( \tau_1 \): 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 5.
- \( \tau_{2,W} \): 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 5.

2.3.6 Hull girder stress for prescriptive buckling check

For prescriptive buckling check of plating according to NI 615, Buckling Assessment of Plated Structures, the hull girder stresses (\( \sigma_{hg}, \tau_{hg} \)) are considered as follow:

- \( \sigma_{hg} = \sigma_{X1} \)
- \( \tau_{hg} = \tau_1 \)

2.3.7 Buckling check criteria

The buckling strength of plating is to satisfy the following criterion:

\[ \eta \leq \eta_{ALL} \quad \text{with: } \eta_{ALL} = 1 \]

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:
  \[ \sigma_{X1} = \gamma_{S1} \sigma_{S1} + \gamma_{W1} (C_{FV} \sigma_{WV1} + C_{FH} \sigma_{WH}) \]
- for longitudinal stiffeners not contributing to the hull girder longitudinal strength:
  \[ \sigma_{X1} = 0 \]
- for transverse stiffeners:
  \[ \sigma_{X1} = 0 \]

where:

- \( \sigma_{S1}, \sigma_{WV1}, \sigma_{WH} \): Hull girder normal stresses, in N/mm², defined in Tab 7
- \( C_{FV}, C_{FH} \): Combination factors given in Tab 8

### Table 6: Ordinary stiffeners - Partial safety factors

<table>
<thead>
<tr>
<th>Partial safety factors covering uncertainties regarding:</th>
<th>Symbol</th>
<th>Yielding check</th>
<th>Testing check</th>
<th>Buckling check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Still water hull girder loads</td>
<td>( \gamma_{S1} )</td>
<td>1,00</td>
<td>0</td>
<td>1,00</td>
</tr>
<tr>
<td>Wave hull girder loads</td>
<td>( \gamma_{W1} )</td>
<td>1,07</td>
<td>1,07</td>
<td>N.A.</td>
</tr>
<tr>
<td>Still water pressure</td>
<td>( \gamma_{S2} )</td>
<td>1,00</td>
<td>1,00</td>
<td>1,00</td>
</tr>
<tr>
<td>Wave pressure</td>
<td>( \gamma_{W2} )</td>
<td>1,07</td>
<td>1,10</td>
<td>1,05</td>
</tr>
<tr>
<td>Material</td>
<td>( \gamma_{m} )</td>
<td>1,02</td>
<td>1,02</td>
<td>1,02</td>
</tr>
<tr>
<td>Resistance</td>
<td>( \gamma_{R} )</td>
<td>1,02</td>
<td>1,02</td>
<td>1,02</td>
</tr>
</tbody>
</table>

(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, \( \gamma_{R} = 1,25 \).

**Note 1:** N.A. = Not applicable.
Table 7: Hull girder normal stresses - Ordinary stiffeners subjected to lateral pressure

<table>
<thead>
<tr>
<th>Condition</th>
<th>( \sigma_{11} ), in N/mm²</th>
<th>( \sigma_{12} ), in N/mm²</th>
<th>( \sigma_{13} ), in N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral pressure applied on the side opposite to the ordinary stiffener, with respect to the plating:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( z \geq N )</td>
<td>( \frac{M_{W,S}(z - N)}{I_y} \times 10^{-3} )</td>
<td>( \frac{M_{W,S}(z - N)}{I_y} \times 10^{-3} )</td>
<td>( \frac{M_{W,S}}{I_y} \times 10^{-3} )</td>
</tr>
<tr>
<td>( z &lt; N )</td>
<td>( \frac{M_{W,S}(z - N)}{I_y} \times 10^{-3} )</td>
<td>( \frac{M_{W,S}(z - N)}{I_y} \times 10^{-3} )</td>
<td>( \frac{M_{W,S}}{I_y} \times 10^{-3} )</td>
</tr>
</tbody>
</table>

Lateral pressure applied on the same side as the ordinary stiffener:

| \( z \geq N \) | \( \frac{M_{W,S}(z - N)}{I_y} \times 10^{-3} \) | \( \frac{M_{W,S}(z - N)}{I_y} \times 10^{-3} \) | \( \frac{M_{W,S}}{I_y} \times 10^{-3} \) |
| \( z < N \) | \( \frac{M_{W,S}(z - N)}{I_y} \times 10^{-3} \) | \( \frac{M_{W,S}(z - N)}{I_y} \times 10^{-3} \) | \( \frac{M_{W,S}}{I_y} \times 10^{-3} \) |

(1) When the ship in still water is always in hogging condition, \( M_{W,S} \) is to be taken equal to 0.

Table 8: Combination factor \( C_{FV} \) and \( C_{FH} \) for stiffeners

<table>
<thead>
<tr>
<th>Load case</th>
<th>( C_{FV} )</th>
<th>( C_{FH} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>“a”</td>
<td>1,0</td>
<td>-</td>
</tr>
<tr>
<td>“b”</td>
<td>0,7</td>
<td>0</td>
</tr>
<tr>
<td>“c”</td>
<td>0,4</td>
<td>1,0</td>
</tr>
<tr>
<td>“d”</td>
<td>0,25</td>
<td>0,7</td>
</tr>
</tbody>
</table>

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.

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:

\[
w = \gamma_s Y_s \lambda_{sh} Y_{sh} \frac{Y_{sh} P_{sh} + Y_{sh} P_{su}}{12 R_y} \left( 1 - \frac{s^2}{2 t^2} \right) s t^3 10^3
\]

\[
A_{sh} = 10 \gamma_s Y_s \lambda_{sh} Y_{sh} \frac{Y_{sh} P_{sh} + Y_{sh} P_{su}}{R_y} \left( 1 - \frac{s^2}{2 t^2} \right) s t
\]

where:

\[
\beta_{sh} \beta_{sh} : \text{Coefficients defined in Tab 9}
\]

Note 1: The bracket length \( \ell_{hs} \) is defined in Pt B, Ch 4, Sec 3 of the Ship Rules. \( \ell_{hs} \) and \( \ell_{sh} \) are the lengths of the two brackets fitted at each end.

Table 9: Coefficients \( \beta_{sh} \) and \( \beta_{sh} \)

<table>
<thead>
<tr>
<th>Brackets at ends</th>
<th>Bracket lengths</th>
<th>( \beta_{sh} )</th>
<th>( \beta_{sh} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>( \ell_{hs} )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>( \ell_{hs} )</td>
<td>( 1 - \frac{\ell_{hs}^2}{2 t^2} )</td>
<td>( 1 - \frac{\ell_{hs}^2}{2 t^2} )</td>
</tr>
<tr>
<td>2</td>
<td>( \ell_{hs} ), ( \ell_{sh} )</td>
<td>( 1 - \frac{\ell_{hs}^2 + \ell_{sh}^2}{2 t^2} )</td>
<td>( 1 - \frac{\ell_{hs}^2 + \ell_{sh}^2}{2 t^2} )</td>
</tr>
</tbody>
</table>

Note 1: The bracket length \( \ell_{hs} \) is defined in Pt B, Ch 4, Sec 3 of the Ship Rules. \( \ell_{hs} \) and \( \ell_{sh} \) are the lengths of the two brackets fitted at each end.

\( \beta_{sh} \beta_{sh} \) : Coefficients defined in Tab 9

\( \alpha_{sh} \) : Coefficient to be taken equal to 0.9.
\( \lambda_n \) : Coefficient taken equal to the greater of the following values:

\[
\lambda_n = 1 + 0,4 \frac{\gamma_{Sd}(P_{Sd} - P_{Su}) + \gamma_{Wd}(P_{Wd} - P_{Wu})}{\gamma_{Sd}(P_{Sd} + P_{Su}) + \gamma_{Wd}(P_{Wd} + P_{Wu})}
\]

\[
\lambda_n = 1 - 0,4 \frac{\gamma_{Sd}(P_{Sd} - P_{Su}) + \gamma_{Wd}(P_{Wd} - P_{Wu})}{\gamma_{Sd}(P_{Sd} + P_{Su}) + \gamma_{Wd}(P_{Wd} + P_{Wu})}
\]

\( \rho_{Sd} \) : Still water pressure, in kN/m², at the lower end of the ordinary stiffener considered

\( \rho_{Su} \) : Still water pressure, in kN/m², at the lower end of the ordinary stiffener considered

\( \rho_{Wd} \) : Wave pressure, in kN/m², at the lower end of the ordinary stiffener considered

\( \rho_{Wu} \) : Wave pressure, in kN/m², at the upper end of the ordinary stiffener considered.

### 3.3.4 Multispan ordinary stiffeners

The maximum normal stress \( \sigma \) and shear stress \( \tau \) 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 5
- 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 \( \sigma \) and shear stress \( \tau \) in a multispan ordinary stiffener are to comply with the following formulae:

\[
\frac{R}{\gamma E Y_m} \geq \sigma
\]

\[
0,5 \frac{R}{\gamma E Y_m} \geq \tau
\]

### 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 cm³, and the net shear sectional area \( A_{sh} \), in cm², of longitudinal or transverse ordinary stiffeners are to be not less than the values obtained from the following formulae:

\[
w = \gamma E Y_m \lambda_n \beta_m \frac{\gamma_{Sd} P_{Sd} + \gamma_{Wd} P_{Wd}}{12 R_y} \left(1 - \frac{s}{2l}\right) s^3 l^3
\]

\[
A_{sh} = 10 \gamma E Y_m \lambda_n \beta_m \frac{\gamma_{Sd} P_{Sd} + \gamma_{Wd} P_{Wd}}{R_y} \left(1 - \frac{s}{2l}\right) s l^2
\]

where:

\( \beta_m, \beta_b \) : Coefficients defined in Tab 9

\( \alpha_s \) : Coefficient to be taken equal to 0.9.

### 3.4.3 Single span vertical ordinary stiffeners

The net section modulus \( w \), in cm³, and the net shear sectional area \( A_{sh} \), in cm², of vertical ordinary stiffeners are to be not less than the values obtained from the following formulae:

\[
w = \gamma E Y_m \lambda_n \beta_m \gamma_{Sd} P_{Sd} + \gamma_{Wd} P_{Wd} \left(1 - \frac{s}{2l}\right) s^3 l^3
\]

\[
A_{sh} = 10 \gamma E Y_m \lambda_n \beta_m \gamma_{Sd} P_{Sd} + \gamma_{Wd} P_{Wd} \left(1 - \frac{s}{2l}\right) s l^2
\]

where:

\( \beta_m, \beta_b, \beta_s \) : Coefficients defined in Tab 9

\( \lambda_n \) : Coefficient taken equal to the greater of the following values:

\[
\lambda_n = 1 + 0,2 \frac{\gamma_{Sd}(P_{Sd} - P_{Sd}) + \gamma_{Wd}(P_{Wd} - P_{Wd})}{\gamma_{Sd}(P_{Sd} + P_{Sd}) + \gamma_{Wd}(P_{Wd} + P_{Wd})}
\]

\[
\lambda_n = 1 - 0,2 \frac{\gamma_{Sd}(P_{Sd} - P_{Sd}) + \gamma_{Wd}(P_{Wd} - P_{Wd})}{\gamma_{Sd}(P_{Sd} + P_{Sd}) + \gamma_{Wd}(P_{Wd} + P_{Wd})}
\]

\( \rho_{Sd} \) : Still water pressure, in kN/m², in flooding conditions, at the lower end of the ordinary stiffener considered (see Ch 1, Sec 5, [6.6])

\( \rho_{Su} \) : Still water pressure, in kN/m², in flooding conditions, at the upper end of the ordinary stiffener considered (see Ch 1, Sec 5, [6.6])

\( \rho_{Wd} \) : Wave pressure, in kN/m², in flooding conditions, at the lower end of the ordinary stiffener considered (see Ch 1, Sec 5, [6.6])

\( \rho_{Wu} \) : Wave pressure, in kN/m², in flooding conditions, at the upper end of the ordinary stiffener considered (see Ch 1, Sec 5, [6.6]).
3.4.4 Multispan ordinary stiffeners

The maximum normal stress $\sigma$ and shear stress $\tau$ 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 5
- 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 $\sigma$ and shear stress $\tau$ in a multispan ordinary stiffener are to comply with the following formulae:

\[
\frac{R_x}{\gamma_T} \geq \sigma
\]
\[
0.5 \frac{R_y}{\gamma_T} \geq \tau
\]

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.

3.6 Net section modulus and net shear sectional area of ordinary stiffeners subject to impact loads

3.6.1 The net section modulus and net shear sectional area of ordinary stiffeners subject to impact loads are to comply with the requirements of Pt B, Ch 7, Sec 2, [3.10] of the Ship Rules.

4 Buckling check of ordinary stiffeners

4.1 Buckling check

4.1.1 General

The buckling check of ordinary stiffeners is to be performed in accordance with NI 615, Buckling Assessment of Plated Structures.

The compression stresses to be taken into account for the checking criteria are calculated with [4.1.2] and [4.1.3].

4.1.2 Hull girder compression normal stresses

The hull girder compression normal stresses to be considered for the buckling check of ordinary stiffeners are obtained, in N/mm², from the following formula:

\[
\sigma_{X1} = \gamma_{S1} \sigma_{S1} + \gamma_{W1} (C_{EV} \sigma_{WW1} + C_{FH} \sigma_{WH})
\]

where:

\[
\sigma_{S1}, \sigma_{WW1}, \sigma_{WH} : \text{Hull girder normal stresses, in N/mm}^2, \text{ defined in Tab 10.}
\]

For longitudinal stiffeners, $\sigma_{X1}$ is to be taken as the maximum compression stress on the stiffener considered.

When the ship in still water is always in hogging condition, $\sigma_{X1}$ 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 5.

With respect to the reference co-ordinate system defined in Ch 1, Sec 1, [3.3], 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:

\[
\sigma_{X1} : \text{Compression normal stress, in N/mm}^2, \text{ induced by the hull girder still water and wave loads, defined in [3.4.2] and [4.1.2]}
\]

\[
\sigma_{X2,S}, \sigma_{X2,W} : \text{Compression normal stress in x and y direction, respectively, in N/mm}^2, \text{ induced by the local bending of the primary supporting members and obtained from a direct structural analysis using the still water design loads as given in Ch 1, Sec 5}
\]

\[
\sigma_{X2,W}, \sigma_{Y2,W} : \text{Compression normal stress in x and y direction, respectively, in N/mm}^2, \text{ induced by the local bending of the primary supporting members and obtained from a direct structural analysis using the wave design loads as given in Ch 1, Sec 5.}
\]

4.1.4 Hull girder stress for prescriptive buckling check

The hull girder stress for the prescriptive buckling check of the stiffener, in accordance with NI615, Buckling Assessment of Plated Structures, is defined in [2.3.6].


4.1.5  Buckling check criteria
The buckling strength of stiffeners is to satisfy the following criterion:

$$\eta \leq \eta_{\text{ALL}} \quad \text{with:} \quad \eta_{\text{ALL}} = 1$$

5  Primary supporting members

5.1  Application

5.1.1  VeriSTAR- Hull
All units covered by the present Chapter are to be granted the additional service feature VeriSTAR-Hull (as stated in Ch 1, Sec 1, [1.2.4]), and are to comply with the requirements of the present Article [5].

5.1.2  VeriSTAR- Hull FLM
In addition, units intended to receive the additional notation VeriSTAR-Hull FLM, as defined in Ch 1, Sec 1, [1.2.5], are to comply with the requirements of NR551 “Structural Analysis of Offshore Surface Units through Full Length Finite Elements Models”.

5.2 General

5.2.1  Net thickness
The net thickness of plating which forms the webs and flanges of primary supporting members are to be checked in accordance with Pt B, Ch 7 and Pt D, Ch 7, Sec 3, [4.3] of the Ship Rules taking into account the requirements of the present Section.

5.2.2  Finite element model
For the checking of the scantlings of 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
- wave loads
- finite element modelling criteria
- loading conditions
- checking criteria
given in the present Chapter.

In addition, design mooring loads and appurtenances design loads defined in Ch 1, Sec 8, [1] and Ch 1, Sec 8, [2] are to be considered in the model for the verification of the Ship area.

5.2.3  Number of models
Each typical cargo tank is to be subject of finite element calculation.

At least three cargo tanks are to be assessed:

- the cargo oil tank at midship (midship model)
- the forward cargo tank (fore model)
- the afterward cargo tank (aft model).

5.3  Partial safety factors

5.3.1  The partial safety factors to be taken into account for the checking of the scantlings of the primary supporting members are given in Tab 11 and in Tab 12.

5.4 Structural modelling

5.4.1  Model construction
The requirements given in Pt B, Ch 7, App 1, [3.1] of the Ship Rules are to be complied with.

5.4.2  Model extension
Model extension is to comply with the requirements of Pt B, Ch 7, App 1, [3.2] of the Ship Rules.

Fore and aft models are to extend over the collision bulkheads.

5.4.3  Boundary conditions
The requirements given in Pt B, Ch 7, App 1, [3.6] of the Ship Rules, as applicable to structural model extended over at least three cargo tanks, are to be complied with.
5.4.4 Finite elements models and modelling criteria

The requirements given in Pt B, Ch 7, App 1, [3.3] and [3.4] of the Ship Rules are to be complied with.

In case of an analysis based on coarse mesh model, the following standard mesh models are to be made:
- transverse rings
- primary supporting members supporting the transverse bulkheads
- bottom and deck girders.

Unit’s structure may be considered as standardly meshed, when each longitudinal ordinary stiffener is modelled; as a consequence, the standard size of elements used for standard mesh is the spacing of ordinary stiffeners.

For fine mesh models, the requirements of [5.4.5] are to be taken into account.

5.4.5 Fine mesh models

Evaluation of detailed stresses requires the use of fine mesh in way of areas of high stress (see [5.6.2] and [5.6.3]). The fine mesh analysis may be performed on separate finite element models, having boundary conditions obtained from the standard mesh model. As an alternative, fine mesh zones incorporated in the standard mesh model may be used.

The extent of fine mesh zone is not to be less than the relevant spacing of ordinary stiffeners in the considered structural region, in all directions from the area under investigation. When separate models are used, the extent is to be such that the calculated stresses within the investigated area are not significantly affected by the imposed boundary conditions and application of loads.

The elements inside the fine mesh zones are to be modelled based on net scantlings, as defined in Ch 1, Sec 3, [4] and Pt B, Ch 4, Sec 2 of the Ship Rules.

All platings inside the fine mesh zone are to be represented by shell elements having dimensions not above 100 mm x 100 mm. Element aspect ratio is to be as close to 1 as possible, and not to exceed 3. Element’s corner angles are to be greater than 60° and less than 120°. Triangular elements and elements having dimensions less than their thickness are to be avoided.

Face plates of primary supporting members or openings are to be modelled with shell elements within the fine mesh zone.

5.5 Load model

5.5.1 Loading conditions

The design on-site loading conditions specified in Fig 1 and Fig 2, as relevant, are to be considered in the analysis of primary supporting members in cargo and ballast tanks.

In addition, 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 maximizing the stresses in the longitudinal structure and primary supporting members. When some of the on-site loading conditions shown in Fig 1 and 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.
When the conditions 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.). For fore and aft models, the loading patterns are to be adjusted considering the capacity plan of the unit in the studied area. The loading conditions selected cases are to maximize internal pressure applied on watertight bulkheads, local shear stress at bulkheads location and torsion on the hull.

Figure 1: Loading conditions for units fitted with one central longitudinal bulkhead for on-site condition

[Diagrams showing loading conditions at maximum draught T, loading condition at draught 0.9T, loading conditions at minimum draught T_min, loading condition at draught 0.75T]
5.5.2 Local loads
The local loads to be taken into account are given in Ch 1, Sec 5.
The loads induced by the topside on deck are to be taken into account.

5.5.3 Hull girder loads
The hull girder loads to be taken into account are given in:
- Tab 13 and Tab 14 for the midship model
- Tab 15 and Tab 16 for the fore and aft models
Note 1: For fore and aft peak analysis, see Ch 1, Sec 8, [3.2] and Ch 1, Sec 8, [4.2] respectively.

5.5.4 Load cases
The loading conditions are to be combined with the load cases with the relevant wave loads and sea pressures as defined in Ch 1, Sec 5.
The sea state's return period for transit and site conditions are defined in Ch 1, Sec 4, [1.1].

Figure 2: Loading conditions for units fitted with two central longitudinal bulkhead for on-site condition
Table 13 : Midship model - Maximal bending moments at the middle of the central tank

<table>
<thead>
<tr>
<th>Ship condition</th>
<th>Load case</th>
<th>Vertical bending moments at the middle of the central tank/hold</th>
<th>Horizontal wave bending moment at the middle of the central tank/hold</th>
<th>Vertical shear forces at the middle of the central tank/hold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upright</td>
<td>“a” crest</td>
<td>$\gamma_1 M_{SW}$</td>
<td>$\gamma_{W1} M_{WVH}$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>“a” trough</td>
<td>$\gamma_1 M_{SW}$</td>
<td>$\gamma_{W1} M_{WVS}$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>“b”</td>
<td>$\gamma_1 M_{SW}$, 0.7 $\gamma_1 M_{WVS}$</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Inclined</td>
<td>“c”</td>
<td>$\gamma_1 M_{SW}$ (1)</td>
<td>0.4 $\gamma_{W1} M_{WV}$</td>
<td>$\gamma_{W1} M_{WV}$</td>
</tr>
<tr>
<td></td>
<td>“d”</td>
<td>$\gamma_1 M_{SW}$ (1), 0.25 $\gamma_1 M_{WV}$ (2)</td>
<td>0.7 $\gamma_{W1} M_{WV}$</td>
<td>0</td>
</tr>
</tbody>
</table>

Note 1: Hull girder loads are to be calculated at the middle of the central tank/hold.
1. $M_{SW}$ is to be taken equal to $M_{SW, H}$ or to $M_{SW, S}$ depending on the loading condition.
2. $M_{WV}$ is to be taken equal to $M_{WV, H}$ or to $M_{WV, S}$ depending on the loading condition.

Table 14 : Midship model - Maximal shear forces in way of the aft bulkhead of the central tank

<table>
<thead>
<tr>
<th>Ship condition</th>
<th>Load case</th>
<th>Vertical bending moments in way of the aft bulkhead of the central tank/hold</th>
<th>Vertical shear forces in way of the aft bulkhead of the central tank/hold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upright</td>
<td>“a” crest</td>
<td>$\gamma_1 M_{SW}$ (1)</td>
<td>$\gamma_{W1} Q_{SW}$</td>
</tr>
<tr>
<td></td>
<td>“a” trough</td>
<td>$\gamma_1 M_{SW}$ (1)</td>
<td>$\gamma_{W1} Q_{SW}$</td>
</tr>
<tr>
<td></td>
<td>“b”</td>
<td>$\gamma_1 M_{SW}$, 0.7 $\gamma_1 M_{WVS}$</td>
<td>$\gamma_{W1} Q_{SW}$ (3)</td>
</tr>
<tr>
<td>Inclined</td>
<td>“c”</td>
<td>$\gamma_1 M_{SW}$ (1)</td>
<td>0.4 $\gamma_{W1} M_{WV}$</td>
</tr>
<tr>
<td></td>
<td>“d”</td>
<td>$\gamma_1 M_{SW}$ (1), 0.25 $\gamma_1 M_{WV}$ (2)</td>
<td>0.7 $\gamma_{W1} M_{WV}$</td>
</tr>
</tbody>
</table>

Note 1: Hull girder loads are to be calculated in way of the aft bulkhead of the central tank.
1. $M_{SW}$ may be taken from the loading manual among the relevant loading conditions in order to maximize the shear forces.

Table 15 : Fore / aft model - Maximal bending moments

<table>
<thead>
<tr>
<th>Ship condition</th>
<th>Load case</th>
<th>Vertical bending moments</th>
<th>Horizontal wave bending moment</th>
<th>Vertical shear forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upright</td>
<td>“a” crest</td>
<td>$\gamma_1 M_{SW}$</td>
<td>$\gamma_{W1} M_{WVH}$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>“a” trough</td>
<td>$\gamma_1 M_{SW}$</td>
<td>$\gamma_{W1} M_{WVS}$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>“b”</td>
<td>$\gamma_1 M_{SW}$, 0.7 $\gamma_1 M_{WVS}$</td>
<td>0</td>
<td>$\gamma_{W1} Q_{SW}$ (3)</td>
</tr>
<tr>
<td>Inclined</td>
<td>“c”</td>
<td>$\gamma_1 M_{SW}$ (1)</td>
<td>0.4 $\gamma_{W1} M_{WV}$</td>
<td>$\gamma_{W1} M_{WV}$</td>
</tr>
<tr>
<td></td>
<td>“d”</td>
<td>$\gamma_1 M_{SW}$ (1), 0.25 $\gamma_1 M_{WV}$ (2)</td>
<td>0.7 $\gamma_{W1} M_{WV}$</td>
<td>$\gamma_{W1} Q_{SW}$ (3)</td>
</tr>
</tbody>
</table>

Note 1: Hull girder loads are to be calculated at the middle of studied region. Several studied region may be necessary in order to obtain the target hull girder loads over the length of the fore/aft model.
1. $M_{SW}$ is to be taken equal to $M_{SW, H}$ or to $M_{SW, S}$ depending on the loading condition.
2. $M_{WV}$ is to be taken equal to $M_{WV, H}$ or to $M_{WV, S}$ depending on the loading condition.
3. $Q_{SW}$ may be taken from the loading manual among the relevant loading conditions in order to maximize the bending moments.

5.6 Yielding strength criteria

5.6.1 Master allowable stress
The master allowable stress, $\sigma_{MASTER}$, in N/mm², is defined by the criteria:

$$\sigma_{MASTER} = \frac{R_y \gamma_m}{\gamma_R}$$

5.6.2 Yielding criteria for coarse and standard mesh analysis
For coarse mesh analysis and standard mesh analysis, for elements located in ship areas (as defined in Ch 1, Sec 1), it is to be checked that the equivalent stress $\sigma_{VM}$, in N/mm², calculated according to Pt B, Ch 7, App 1, [5] of the Ship Rules is in compliance with the following criteria:

$$\sigma_{VM} \leq \sigma_{MASTER}$$

Areas where the equivalent stress $\sigma_{VM}$ obtained through standard mesh analysis is above 0.95$\sigma_{MASTER}$ are to be investigated through fine mesh analysis based on the requirements of [5.4.5] and the criteria given in [5.6.4] are to be checked. The Society may require additional fine mesh analyses for areas where the assessment through standard mesh models is not judged as satisfactory.
### Table 16: Fore / aft model - Maximal shear forces

<table>
<thead>
<tr>
<th>Ship condition</th>
<th>Load case</th>
<th>Vertical bending moments</th>
<th>Horizontal wave bending moment</th>
<th>Vertical shear forces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Still water</td>
<td>Wave</td>
<td>Still water</td>
</tr>
<tr>
<td><strong>Upright</strong></td>
<td>“a” crest</td>
<td>(\gamma_S)</td>
<td>(M_{SW}) (3)</td>
<td>(\gamma_W M_{WV,SH})</td>
</tr>
<tr>
<td></td>
<td>“a” trough</td>
<td>(\gamma_S)</td>
<td>(M_{SW}) (3)</td>
<td>(\gamma_W M_{WV,SH})</td>
</tr>
<tr>
<td></td>
<td>“b”</td>
<td>(\gamma_S)</td>
<td>(M_{SW}) (3)</td>
<td>0,7 (\gamma_W M_{WV,SH})</td>
</tr>
<tr>
<td><strong>Inclined</strong></td>
<td>“c”</td>
<td>(\gamma_S)</td>
<td>(M_{SW}) (1) (3)</td>
<td>0,4 (\gamma_W M_{WV,SH}) (2)</td>
</tr>
<tr>
<td></td>
<td>“d”</td>
<td>(\gamma_S)</td>
<td>(M_{SW}) (1) (3)</td>
<td>0,25 (\gamma_W M_{WV,SH}) (2)</td>
</tr>
</tbody>
</table>

Note 1: Hull girder loads are to be calculated at the middle of studied region. Several studied region may be necessary in order to obtain the target hull girder loads over the length of the fore/aft model.

(1) \(M_{SW}\) is to be taken equal to \(M_{WV,SH}\) or to \(M_{WV,SH}\) depending on the loading condition.

(2) \(M_{SW}\) is to be taken equal to \(M_{WV,SH}\) or to \(M_{WV,SH}\) depending on the loading condition.

(3) \(M_{SW}\) may be taken from the loading manual among the relevant loading conditions in order to maximize the shear forces.

### 5.6.3 Yielding criteria for face plates of primary supporting members and openings

For standard mesh analysis, face plates of primary supporting members and openings may be modelled by shell elements or by beam/bar elements.

When shell elements are used, the requirements of [5.6.2] are to be complied with.

When beam/bar elements are used, it is to be checked that the beam/bar element's axial stress \(\sigma_{ax}\) in N/mm², is in compliance with the following criteria:

\[ \sigma_{ax} \leq \sigma_{MASTER} \]

Areas where the beam/bar element's axial stress \(\sigma_{ax}\) is above 0.95 \(\sigma_{MASTER}\) are to be investigated through fine mesh analysis (with shell elements) based on the requirements of [5.4.5] and the criteria given in [5.6.4] are to be checked.

Note 1: Values of beam/bar element's axial stress are generally calculated by finite element software. The direct use of nodal stresses is to be avoided. When different values of beam element's axial stress are calculated for each extremity of the element, both extremity values are to be checked.

### 5.6.4 Yielding criteria for fine mesh analysis

For fine mesh analysis required in [5.6.2] and/or [5.6.3] and complying with the requirements of [5.4.5], the following criteria are to be checked:

a) Average area:

The average Von Mises equivalent stress \(\sigma_{VM,av}\) as defined in [5.6.5], is to comply with the following criteria:

\[ \sigma_{VM,av} \leq \sigma_{MASTER} \]

b) Isolated mesh:

The equivalent stress \(\sigma_{VM}\) of each (100 mm x 100 mm) element in the fine mesh region excluding the area of structural discontinuity, in N/mm², calculated according to Pt B, Ch 7, App 1, [5] of the Ship Rules, is to comply with the following criteria:

\[ \begin{align*}
\sigma_{VM} & \leq 1,42 \sigma_{MASTER} \\
\sigma_{VM} & \leq 1,3 \sigma_{MASTER}
\end{align*} \]

In case of mesh finer than (100 mm x 100 mm), the equivalent stress \(\sigma_{VM}\) is to be obtained by averaging over an equivalent area of (100 mm x 100 mm), based on the methodology given in [5.6.5].

### 5.6.5 Stress averaging on fine mesh

For the purpose of the criteria given in [5.6.4], item a), the average Von Mises equivalent stress \(\sigma_{VM,av}\) is to be calculated based on weighted average against element areas:

\[ \sigma_{VM,av} = \frac{\sum_{i=1}^{n} \sigma_{VM,i} A_i}{\sum_{i=1}^{n} A_i} \]

where:

\[ \begin{align*}
\sigma_{VM,av} & : \text{Average Von Mises equivalent stress, in N/mm}^2 \\
\sigma_{VM,i} & : \text{Von Mises stress of the i-th element within the considered area, in N/mm}^2 \\
A_i & : \text{Area of the i-th element within the considered area, in mm}^2 \\
n & : \text{Number of elements within the considered area}
\end{align*} \]
Stress averaging is to be performed over an area defined as follows:

- the area considered for stress averaging is to have a size not above the relevant spacing of ordinary stiffeners (s x s)
- for fine mesh along rounded edges (openings, rounded brackets) the area considered for stress averaging is to be limited only to the first ring of border elements, over a length not above the relevant spacing of ordinary stiffeners (see Fig 3 and Fig 4).
- the area considered for stress averaging is to include an entire number of elements
- the area considered for stress averaging is not to be defined across structural discontinuities, web stiffeners or other abutting structure.
- for regions where several different stress averaging areas may be defined, the worst is to be considered for the calculation of average Von Mises equivalent stress.

5.6.6 Particular requirements

Particular attention is to be paid to the stress flow along the studied structural member.

For fine mesh regions located on bracket webs in the vicinity of bracket toes, where an equivalent (s x s) area cannot be defined, the yielding check is to be based only on the criteria given in [5.6.4], item b).

Other structural details having shapes not allowing the stress averaging as required in [5.6.5] are to be specially considered by the Society, based on engineering judgment related to plastic redistribution ability.

5.7 Buckling check

5.7.1 A local buckling check is to be carried out, according to [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].

5.7.2 The buckling criteria for plate panels is to satisfy the following criterion:

\[ \eta \leq \eta_{ALL} \quad \text{with:} \quad \eta_{ALL} = 1 \]

5.7.3 The compressive buckling strength of struts, pillars and cross ties is to satisfy the following criterion:

\[ \eta \leq \eta_{ALL} \quad \text{with:} \quad \eta_{ALL} = 0.75 \]

6 Fatigue check of structural details

6.1 General

6.1.1 The structural details to be checked are those defined in [6.2].

The Society may require other details to be checked, when deemed necessary on the basis of the detail geometry and stress level.

6.1.2 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 to be greater than 20 years, on site conditions.

6.1.3 Fatigue calculation is to be provided to the Society for design review.
6.1.4 For units intended to be granted the additional notation spectral fatigue, as defined in Pt A, Ch 1, Sec 2, [8.4.4], this calculation is to be a spectral fatigue analysis performed according to [6.3] and N1611 “Guidelines for Fatigue Assessment of Steel Ships and Offshore Units”.

For all other units a deterministic fatigue calculation is to be carried out according to [6.4]. Deterministic fatigue calculation may be also carried out at pre-design stage, or for verification of the spectral fatigue calculation.

6.1.5 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.

6.2 Structural details

6.2.1 The structural details to be checked are those defined in Pt B, Ch 11, App 2 of the Ship Rules for the service notation oil tanker ESP.

6.2.2 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 longitudinal with:
     - transverse oiltight and 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.

6.3 Spectral fatigue analysis

6.3.1 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

6.3.2 The spectral fatigue analysis is to take into account at least, except duly justified:

- 3 internal loading conditions, including minimum and maximum draughts
- 25 headings
- 25 frequencies

6.3.3 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.

6.3.4 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).

6.3.5 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.

6.3.6 The fatigue damage is evaluated from the distribution of stress ranges, by the Miner Sum.

<table>
<thead>
<tr>
<th>Consequence of failure</th>
<th>Degree of accessibility for inspection, maintenance and repair</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not accessible (2)</td>
</tr>
<tr>
<td>Critical (1)</td>
<td>0,1</td>
</tr>
<tr>
<td>Non-critical</td>
<td>0,2</td>
</tr>
</tbody>
</table>

(1) Critical damage includes loss of life, uncontrolled pollution, collision, sinking, other major damage to the installations and major production losses. All the structural elements are to be considered as critical, unless duly justified by an analysis of the consequences of failure.

(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.

Table 17: Damage ratio for spectral fatigue analysis
6.3.7 Checking criteria
For the spectral fatigue analysis, the fatigue damage ratio is to be not greater than those given in Tab 17.

6.4 Deterministic fatigue analysis

6.4.1 General
Deterministic fatigue analysis is to be conducted with loads defined in [6.4.3] partial safety factors defined in [6.4.2] and checking criteria defined in [6.4.9].

6.4.2 Partial safety factors
The partial safety factors to be taken into account are those given in Tab 18.

**Table 18: Fatigue check – Partial safety factors**

<table>
<thead>
<tr>
<th>Partial safety factors covering uncertainties regarding:</th>
<th>Symbol</th>
<th>Value</th>
<th>Details at ends of ordinary stiffeners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Still water hull girder loads</td>
<td>γS1</td>
<td>1,00</td>
<td>1,00</td>
</tr>
<tr>
<td>Wave hull girder loads</td>
<td>γW1</td>
<td>1,03</td>
<td>1,11</td>
</tr>
<tr>
<td>Still water pressure</td>
<td>γS2</td>
<td>1,00</td>
<td>1,00</td>
</tr>
<tr>
<td>Wave pressure</td>
<td>γW2</td>
<td>1,07</td>
<td>1,15</td>
</tr>
<tr>
<td>Resistance</td>
<td>γR</td>
<td>1,02</td>
<td>1,02</td>
</tr>
</tbody>
</table>

6.4.3 Loads
The loads to consider for deterministic fatigue analysis are the design wave loads defined in Ch 1, Sec 5 and taken to a probability level of $10^{-5}$.

The loads to be determined are the following ones:
- vertical wave bending moment
- accelerations
- relative wave elevation.

6.4.4 Loading conditions
The calculations are generally to be carried out for 4 loading conditions with their associated draughts $T_i$ as defined in Tab 19, 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 19: Loading conditions**

<table>
<thead>
<tr>
<th>Draught $T_i$</th>
<th>Loading condition “i”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum $T_{\text{max}}$</td>
<td>Full load</td>
</tr>
<tr>
<td>Intermediate 1</td>
<td>Case by case</td>
</tr>
<tr>
<td>By default: $2/3 , T_{\text{max}} + 1/3 , T_{\text{mini}}$</td>
<td>By default: full load</td>
</tr>
<tr>
<td>Intermediate 2</td>
<td>Case by case</td>
</tr>
<tr>
<td>By default: $1/3 , T_{\text{max}} + 2/3 , T_{\text{mini}}$</td>
<td>By default: ballast</td>
</tr>
<tr>
<td>Minimum $T_{\text{mini}}$</td>
<td>Ballast</td>
</tr>
</tbody>
</table>

6.4.5 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 $\alpha_0$ equal to 1.

6.4.6 Cumulative damage ratio
The cumulative damage ratio is to be obtained from the following formula:

$$D = \frac{1}{\beta_{\text{IF}}} \left( K_{\text{cor}} \sum_{i=1}^{4} \alpha_i D_i \right)$$

where:

$\alpha_i$ : 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 $\alpha_i$ coefficients:

$$\sum_{i=1}^{4} \alpha_i = 1$$

$\beta_{\text{IF}}$ : Fatigue life improvement factor for improvement technique, if any, as defined in:
- [6.4.7] in case of grinding
- [6.4.8] for improvement techniques other than grinding

$\beta_{\text{IF}} = 1.0$ if no improvement technique is used.

$D_i$ : Cumulative damage ratio for unit in loading condition “i”

$$D_i = \beta_{\text{ab}} D_{\text{a}} + \beta_{\text{c}} D_{\text{c}} + \beta_{\text{d}} D_{\text{d}}$$

$\beta_{\text{ab}}, \beta_{\text{c}}, \beta_{\text{d}}$: Distribution coefficients for load cases “a”, “b”, “c” and “d”, as defined in Tab 20

Other values may be considered on a case by case basis.

$D_{\text{a}}, D_{\text{b}}, D_{\text{c}}, D_{\text{d}}$: Elementary damage ratios for load cases “a”, “b”, “c” and “d”, respectively, in loading condition “i”, as defined in [6.4.5]

$K_{\text{cor}}$ : Corrosion factor, equal to:
- $K_{\text{cor}} = 1,5$ for cargo oil tanks
- $K_{\text{cor}} = 1,1$ for ballast tanks having an effective coating protection.

**Table 20: Distribution coefficients**

<table>
<thead>
<tr>
<th>$T_i \geq \frac{T_{\text{mini}} + T_{\text{max}}}{2}$</th>
<th>$T_i \leq \frac{T_{\text{mini}} + T_{\text{max}}}{2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_{\text{ab}}$</td>
<td>1/3</td>
</tr>
<tr>
<td>$\beta_{\text{c}}$</td>
<td>1/3</td>
</tr>
<tr>
<td>$\beta_{\text{d}}$</td>
<td>1/3</td>
</tr>
</tbody>
</table>
6.4.7  Grinding of welds
Grinding technique for improving fatigue life is applicable to full penetration welds.

Grinding of welds is to be regarded as an exceptional measure considered case by case, and only when the design fatigue life cannot be achieved by the design (such as improvements of shape of cut-outs, softening of bracket toes and local increase in thickness) and geometry of the structural detail.

In such a case:
- the information “grinding of welds”, with indication of the toe to be ground, is to be specified by the designer on drawings
- the relevant grinding procedure, according to Ch 1, Sec 9, [2.2], is to be submitted to the Society by the designer for review
- the fatigue life improvement factor $\beta_{fr}$, as defined in [6.4.6], may be taken equal to 2.2, provided that a permanent protective coating is applied on the ground weld. Otherwise, the value of $\beta_{fr}$ is considered by the Society on a case by case basis.

6.4.8  Improvement techniques other than grinding of welds
Improving fatigue life by using improvement techniques other than grinding is to be regarded as an exceptional measure. Such improvement techniques may be considered by the Society on a case by case basis. In such a case, the fatigue life improvement factor $\beta_{fr}$, as defined in [6.4.6], is to be duly justified by the designer.

6.4.9  Checking criteria
The cumulative damage ratio defined in [6.4.6] is to comply with the following criteria:

$$SF \times D \leq \frac{1}{\gamma_c}$$

where:
- $SF = 2$
- $\gamma_c$: Partial safety factor defined in [6.4.2].

Note 1: In case that all hydrodynamic values and distributions are lower than minimum or rule values and distribution with significant margin (as a rule hydrodynamic loads lower than 25% of the rule loads), a Safety Factor SF lower than 2 may be considered by the Society.

6.4.10  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:
\[
c_a = 1.21 \left( \frac{1 + 0.33 \left( \frac{s}{\ell} \right)^2}{\ell} \right) - 0.69 \left( \frac{s}{\ell} \right)^2
\]
to be taken not greater than 1.0

\( c_r \) : Coefficient of curvature of the panel, equal to:
\[
c_r = 1 - 0.5 \frac{s}{\ell}
\]
to be taken not less than 0.5

\( \ell \) : Length, in m, of the longer side of the plate panel

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

\( \alpha_p \) : Correction coefficient defined as follows:
\[
\alpha_p = 1.2 - \frac{s}{2.1 \ell}
\]
without being taken greater than 1.0

\( C_d \) : Plate capacity correction coefficient:
- \( C_d = 1.0 \) for flat bottom forward impact
- \( C_d = 1.2 \) for bow flare impact

\( n_s \) : Number of fixed ends of stiffener:
- \( n_s = 2 \) for continuous members or members with brackets fitted at both ends
- \( n_s = 1 \) for one end equivalent to built-in and the other end simply supported
- \( n_s = 0 \) for both ends with low end fixity

\( t_p \) : Attached plating net thickness, in mm.

\( h_w \) : height of the web stiffeners

\( R_{EG} \) : Minimum specified yield stress of the material

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 Rule Note NR493, Classification of Mooring Systems for Permanent Offshore Units.

The present Article [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 of 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 of the bow, externally of the structure:
  A local model is to be made.
- within the forward structure, forward of the cargo tank area:
  As a rule, the structure is to be modelled from the bow to the aft end of the cargo tank No.1. The model may be clamped in way of the transverse bulkhead located at the aft end of the cargo tank No.1.

Note 1: For this calculation, there is no need of model balancing, but the masses 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 of the turret area. The model may be clamped at the end of one adjacent cargo tank. The model should be balanced by an 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.

As a rule, a heading analysis is mandatory as defined in Ch 1, Sec 4, [5.3.3]. Depending on the heading analysis results, load case d) may be disregarded for yield and buckling checks subject to the Society approval.

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.

1.3 Spread mooring system

1.3.1 General

The structure supporting the equipment of the mooring system (as defined in NR493, 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 Appendix 3 of NR493, 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 for at least the two following draughts:
  - minimum draught
  - maximum draught.

Design loading conditions defined in Tab 1 may be used as a guidance.

1.4.3 Checking criteria

Allowable stresses are those given in Pt B, Ch 3, Sec 3, [5]. Buckling is to be checked according to Pt B, Ch 3, Sec 3, [6].

For fatigue analysis, the damage ratio is to be not greater than those given in Ch 1, Sec 7, Tab 17.

1.4.4 Materials and testing

For the steel grade selection, the structure supporting the equipment of the mooring system is considered as offshore area (see Ch 1, Sec 3).
<table>
<thead>
<tr>
<th>Load case</th>
<th>System condition</th>
<th>Design loads</th>
<th>Environment to be considered</th>
<th>Basic allowable stress factor $\alpha$ (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design / Installation</td>
<td>Mooring line installation load on fairlead sheave</td>
<td>One mooring line with installation load (1) Other mooring lines with pretension</td>
<td>Installation angles</td>
<td>$\alpha = 0,8$</td>
</tr>
<tr>
<td>Design / Intact</td>
<td>Normal operation</td>
<td>Design tension on each mooring line</td>
<td>1 year return period</td>
<td>$\alpha = 0,8$</td>
</tr>
<tr>
<td>Design / Damaged</td>
<td>One broken mooring line</td>
<td>One mooring line broken Other lines with design tension (mooring analysis with one line broken to be considered)</td>
<td>100 years return period</td>
<td>$\alpha = 0,8$</td>
</tr>
<tr>
<td>Accidental</td>
<td>Minimum Breaking Load (MBL) on one mooring line</td>
<td>One mooring line with MBL Adjacent lines with intact design tension</td>
<td>100 years return period</td>
<td>$\alpha = 1,0$</td>
</tr>
</tbody>
</table>

(1) The installation design load is defined as the greater of:
- 1,33 times the SWL of the considered equipment
- the brake load of the winch or the holding capacity of the jacking system used for tensioning.

(2) The maximum values of $\beta$ obtained by mooring analysis may also be used.

(3) As defined in Pt B, Ch 3, Sec 3, [5]. Factor $\alpha$ is given in this Table as an indication of safety level for each design loading condition.

**Note 1:** For each load case, wave loads are to be combined as follows:
- maximum draft with adjacent empty capacities and load case a+ (hogging equilibrium)
- minimum draft with adjacent fully loaded and load cases a- and b (sagging equilibrium).

---

**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 (see [2.1.4])
- lifting appliances (see [2.1.5])
- 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]. The strength assessment is to cover also the ship areas adjacent to the offshore areas as deemed necessary.

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 the following four conditions:

- static conditions, with \( \alpha = 0.6 \)
- design conditions, with \( \alpha = 0.8 \)
- transit towing conditions, with \( \alpha = 0.8 \)
- accidental cases, with \( \alpha = 1.0 \)

where:

\[ \alpha \] : Basic allowable stress factor defined in Pt B, Ch 3, Sec 3, [5].

### 2.1.4 Flare tower foundation

For flare tower foundation, design loading conditions defined in Tab 2 may be used as a guidance.

### 2.1.5 Lifting appliances foundations

For lifting appliances foundations, design loading conditions defined in NR608 Classification of lifting units are to be considered.

### 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, [3.3]
- the forces generated by the support structure on the hull.

#### 2.2.3 Checking criteria

Allowable stresses are those given in Pt B, Ch 3, Sec 3, [5]. Buckling is to be checked according to Pt B, Ch 3, Sec 3, [6].

For fatigue analysis, the damage ratio is to be not greater than the values given in Ch 1, Sec 7, Tab 17.

#### 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).

#### 2.2.5 Corrosion additions

The structure is to be modelled in net scantlings. Corrosion additions, as defined in Ch 1, Sec 3, [4] are to be considered as a minimum.

### 3 Fore part

#### 3.1 Application

The requirements of this Article apply for the scantlings of structures located forward of the collision bulkhead, if any, i.e.:

- fore peak structure,
- stem.

In addition, it includes:

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

#### 3.1.2 The fore part of the unit is defined in Ch 1, Sec 1, [3.2.8].

The fore part may differ in site and transit conditions.
3.2 Fore peak

3.2.1 General

The scantlings and the arrangement of the fore peak are to be in accordance with the requirements of Pt B, Ch 8, Sec 1 of the Ship Rules but using the design loads given in Ch 1, Sec 5 and the partial safety factors defined in:

- Ch 1, Sec 7, Tab 1 for plating
- Ch 1, Sec 7, Tab 6 for stiffeners
- Ch 1, Sec 7, Tab 12 for primary supporting members.

3.2.2 Finite element analysis

When a finite element analysis, as defined in Ch 1, Sec 7, is performed in order to verify the scantlings of the fore peak structure, the hull girder loads do not need to be considered.

Note 1: For units provided with an external turret, the hull girder loads are to be considered on a case-by-case basis.

3.3 Reinforcements of the flat bottom forward area

3.3.1 General

The flat bottom forward area is to be assessed for both transit and site conditions.

Alternative method may be accepted on a case-by-case basis.

3.3.2 Area to be reinforced

In addition to the requirements in [3.2], 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 extends:

- longitudinally, over the bottom located between $\xi L$ and 0.05 L aft of the fore end, where the coefficient $\xi$ is obtained from the following formula:
  $\xi = 0.25 \left( 1.6 - C_B \right)$
  without being taken less than 0,20 or greater than 0,25
- transversely, over the whole flat bottom and the adjacent zones up to a height, in mm, from the base line, not less than 2 L. In any case, it is not necessary that such height be greater than 300 mm.

3.3.3 Conditions of impact

The bottom dynamic impact pressure is to be considered if:

$T_F < \min \left( 0.04 L; 8.6 \right)$

where:

$T_F$ : Minimum forward draught, in m, among those foreseen in operation

The value of $T_F$ 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.

3.3.4 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 $L \leq 135$

$p_{BI} = (1510 - 2.5 L) C_1 C_{SL}$ if $L > 135$

where:

$C_1 = \frac{119 - 2300 T_F}{78 + 1800 T_F}$ L

$T_F$ : Draught defined in [3.3.3]

$C_{SL}$ : Longitudinal distribution factor, taken equal to:

$C_{SL} = 0$ for $x \leq x_1$

$C_{SL} = \frac{x - x_1}{x_2 - x_1}$ for $x_1 < x < x_2$

$C_{SL} = 1$ for $x \geq x_2$

$x_1 = \left( 0.55 + \frac{L}{2000} \right) L$

$x_2 = \left( 0.35 + 0.5 C_B + \frac{L}{3000} \right) L$ with $0.60 \leq C_B \leq 0.85$

Note 1: When $f_{max}$, as defined in Ch 1, Sec 5, is greater than 1, bow impact pressure should be considered on a case-by-case basis.

3.3.5 Scantlings

In addition to the requirements in Pt B, Ch 8, Sec 1, [2.4.1] and Pt B, Ch 8, Sec 1, [2.5.1] of the Ship Rules, the net scantlings of plating and net plastic section modulus of the ordinary stiffeners of the flat bottom forward area, defined in [3.3.2] and [3.3.3], are to be not less than the values obtained from the formulae in Tab 3 taking into account the minimum values given 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 7, Sec 3 of the Ship Rules, taking into account a pressure of 0.3 $p_{BI}$ over the ship breadth and, in the longitudinal direction, over one floor spacing.

3.3.6 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 8, Sec 1, [3.5] of the Ship Rules for longitudinally framed bottom, or
- Pt B, Ch 8, Sec 1, [3.6] of the Ship Rules for transversely framed double bottom.
3.4 Reinforcements of the bow area

3.4.1 General
The bow area is to be assessed for both transit and site conditions.
Alternative method may be accepted on a case-by-case basis.

3.4.2 Area to be reinforced
In addition to the requirements in [3.2], the structures of the bow area are to be able to sustain the dynamic pressures due to the bow impact pressure.
The bow area to be reinforced is the area extending forward of 0.9 L from the aft end and, vertically, above the minimum draught, as defined in Ch 1, Sec 1, [3.2.11].

3.4.3 Bow impact pressure
The bow impact pressure pFI 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 \( L \geq 80 \) 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
- \( \alpha \) : 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 3)
- \( \beta \) : 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 3)
- \( k \) : Parameter to be taken equal to:
  - for on-site conditions: \( k = 4.8 \)
  - for transit conditions: \( k = 0.4 V_L \)
The Society may accept a reduced value for k on a case-by-case basis.

Note 1: When \( f_{RWE} \), as defined in Ch 1, Sec 5, is greater than 1, bow impact pressure should be considered on a case-by-case basis.

3.4.4 Scantlings
In addition to the requirements in Pt B, Ch 8, Sec 1, [2.6.1] and Pt B, Ch 8, Sec 1, [2.7.1] of the Ship Rules, the net scantlings of plating and ordinary stiffeners of the bow area, defined in [3.4.2], are to be not less than the values obtained from the formulae in Tab 4 and the minimum values given in the same Table.

### Table 3: Reinforcements of plating and ordinary stiffeners of the flat bottom forward area

<table>
<thead>
<tr>
<th>Element</th>
<th>Formula</th>
<th>Minimum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plating</td>
<td>Net thickness, in mm: ( t = \frac{15.8 x 0.5}{C_d} ) ( P_{BS} ) \sqrt{R_{SG}} )</td>
<td>Net minimum thickness, in mm: ( t = (0.03 L + 5.5) k^{1/2} ) where k is the material factor defined in Ch 1, Sec 7</td>
</tr>
</tbody>
</table>
| Ordinary stiffeners | Net plastic section modulus, in cm³: \( Z_{pl} = \frac{P_{BS}}{0.9 x 4 (n_+ 2) R_{SG}} \sqrt{10^3} \) | Net minimum web thickness, in mm, to be not less than the lesser of:  
  - \( t = 1.5 L^{1/3} k^{1/6} \) where k is the material factor defined in Ch 1, Sec 7  
  - the net thickness of the attached plating |
|                 | Net web thickness sectional area, in mm: \( t_w = \frac{\sqrt{2}}{2} \frac{P_{BS}}{h_w + t_j} R_{SG} \) \( s \sqrt{10^3} \) |                                                                                 |

![Figure 3: Definition of angles α and β](image-url)
Table 4 : Reinforcements of plating and ordinary stiffeners of the bow area

<table>
<thead>
<tr>
<th>Element</th>
<th>Formula</th>
<th>Minimum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plating</td>
<td>Net thickness, in mm: $t = \frac{15,8\alpha_s \beta_{pl}}{C_{pl}}$</td>
<td>Net minimum thickness, in mm: $t = (0,03 L + 5,5) k^{1/2}$ where $k$ is the material factor defined in Ch 1, Sec 7</td>
</tr>
<tr>
<td>Ordinary stiffeners</td>
<td>Net plastic section modulus, in cm$^3$: $Z_{pl} = \frac{P_{pl}}{0,9 \times 4(n_1 + 2)R_{og}} \times 10^3$</td>
<td>Net minimum web thickness, in mm, to be not less than the lesser of: - $t = 1,5 L^{1/3} k^{1/6}$ where $k$ is the material factor defined in Ch 1, Sec 7 - the net thickness of the attached plating</td>
</tr>
<tr>
<td></td>
<td>Net web thickness sectional area, in mm: $t_w = \frac{\sqrt{3}}{2} \frac{n_1}{P_{pl} + \epsilon} \times 10^3$</td>
<td></td>
</tr>
</tbody>
</table>

Outside the bow 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 $70^\circ$.

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 [3.4.3].

4 Aft part

4.1 Application

4.1.1 The requirements of this Article apply for the scantlings of structures located aft of the after peak bulkhead, if any, and for the reinforcements of the aft part due to sea impact pressure.

4.1.2 The aft part of the unit is defined in Ch 1, Sec 1, [3.2.8].

The aft part may differ in site and transit conditions.

4.2 Aft peak

4.2.1 The aft peak arrangement is to be in accordance with Pt B, Ch 8, Sec 2 of the Ship Rules but using the design loads given in Ch 1, Sec 5 and the partial safety factors defined in:

- Ch 1, Sec 7, Tab 1 for plating
- Ch 1, Sec 7, Tab 6 for stiffeners
- Ch 1, Sec 7, Tab 12 for primary supporting members.

4.2.2 Finite element analysis

When a finite element analysis, as defined in Ch 1, Sec 7, [5], is performed in order to verify the scantlings of the aft peak structure, the hull girder loads do not need to be considered.

4.3 Reinforcements of the bottom and aft areas

4.3.1 Spread mooring

In case of spread mooring, the Society may request reinforcements according to [3.3] and [3.4] for the aft part.

4.3.2 Turret mooring

In case of turret mooring system, the aft part does not need to be assessed according to [3.3] and [3.4].

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 8, Sec 4 of the Ship Rules.

5.1.2 When the superstructures are not directly located on the freeboard 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 8, Sec 4, [2] of the Ship Rules, considering that:

- 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 a second tier of 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 a third tier of superstructure, and so on.

6 Helicopter deck

6.1 General

6.1.1 The requirements for the arrangement and structure of helidecks are given in Pt B, Ch 3, Sec 4, [4].
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 9, Sec 2 of the Ship Rules.

7.1.2 In case of large bulwarks, a direct calculation (including fatigue calculations) may be requested by the Society.

7.2 Towing foundation

7.2.1 The towing foundation is to be in accordance with Pt B, Ch 2, Sec 3, [4.2] and Pt B, Ch 3, Sec 3, [5.4].

8 Launching appliances

8.1 Deck ordinary stiffeners in way of launching appliances used for survival craft or rescue boat

8.1.1 Deck structure in way of such appliances is to be considered as ship area and is to fulfil the requirements of:

- Pt B, Ch 7, Sec 2 [2.5] of the Ship Rules for ordinary stiffeners
- Pt B, Ch 7, Sec 3 [2.2] of the Ship Rules for primary supporting members
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, [5.2].

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 Grinding of welds for fatigue life improvement

2.2.1 General
The purpose of grinding is to smoothly blend the transition between the plate and the weld face.

Grinding is generally to be burr grinding. However other techniques of grinding may be considered by the Society on a case by case basis.
2.2.2 Grinding practice

The burr radius \( r \) is generally to be taken greater than 0.6 \( t \), where \( t \) is the plate thickness at the weld toe being ground. In general, grinding must extend to a depth below any visible undercut. However, the grinding depth \( d \), in mm, is to be not greater than:

\[
d = \begin{cases} 
1 \text{ mm} & \text{for } t \geq 14 \\
0.07 t & \text{for } 10 \leq t < 14 
\end{cases}
\]

where \( t \) is the plate thickness, in mm, at the weld toe being ground.

For plate thickness less than 10 mm, grinding is generally not allowed.

After grinding, the weld is to be inspected by the yard quality control in order to check that the finished ground surface is as smooth as possible, with no visible evidence of the original weld toe or undercut or any grinding marks at right angles to the weld toe line. In addition, the Society may require measurements of the remaining thickness in way of the ground weld.

2.2.3 Grinding procedure

The grinding procedure required in Ch 1, Sec 7, [6.4.7] is to specify the following items:

- weld preparation
- grinding tool used
- position of the tool over the weld toe
- location of weld toe on which grinding is applied
- extent of grinding at the ends of attachments
- final weld profile
- final examination technique, including NDE.

2.3 Fatigue resistance assessment

2.3.1 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.

2.3.2 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.

2.3.3 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 Accidental loads

3.1 Analysis

3.1.1 A risk analysis should be performed to assess the risk of explosion, collision and dropped objects.

3.1.2 As a Rule, when finite element analysis are performed, the structural model for the calculations is to be built on net scantlings, as defined in Ch 1, Sec 3, [4].

3.2 Protection to explosions

3.2.1 The verification of the hull structures with respect to explosions are to comply with requirements defined in Pt B, Ch 3, Sec 9, [2].

3.3 Collision

3.3.1 The verification of the hull structures with respect to collision are to comply with requirements defined in Pt B, Ch 3, Sec 9, [3] as applicable for minor or major collisions.

3.4 Dropped objects

3.4.1 The verification of the hull structures with respect to dropped objects are to comply with requirements defined in Pt B, Ch 3, Sec 9, [4].
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 preset 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 rooms

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 avoids air pockets. In particular:

- 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.
- 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.
- The foregoing exhaust system is in association with open grating floor plates to allow the free flow of air.
- 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 be led direct to atmosphere at a safe place on open deck, and are not to pass through 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, [3.6.9]).

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, [3.3.2] 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 shelf 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.

1.6 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 Deck spills

1.7.1 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. refer to Ch 1, Sec 11, [7.5.5] d).
1.7.2 Where gutter bars are installed on the weather decks of units and are extended aft as far as the aft bulkhead of superstructures for the purpose of containing cargo spills on deck, the free surface effects caused by containment of a cargo spill during operations or of unit's movements and accelerations (considering applicable environmental conditions for operations) are to be considered with respect to the vessel's available margin of positive initial stability (refer to Ch 1, Sec 2, [2.1.2]).

1.7.3 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 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.

1.7.4 Means are to be provided to drain and collect to a safe location spills on deck.

1.8 Spaces at non-manned end of the unit-air locks

1.8.1 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 accommodation block. In case such an agreement is considered for spaces other than the spaces opposite to accommodation 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.

1.8.2 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.

1.8.3 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.

1.8.4 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.

1.8.5 The air lock may have more than two doors, in which case, the arrangements stated in [1.8.2] 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.

1.8.6 It is reminded that, in accordance with Part C, Chapter 4, the store for paints is to be fitted with certified sale lighting irrespective of their arrangement.

1.8.7 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 [1.8.3], 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 venting 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 under-pressure 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 from deck machinery and equipment which may constitute an ignition hazard.

Note 1: The height requirements of items c) and d) 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/vacuum valves

a) Pressure/vacuum valves are to be set at a positive pressure not exceeding 0,021 N/mm² and at a negative pressure not exceeding 0,007 N/mm².

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) 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).

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 inert gas 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 and all other outlets are being simultaneously supplied with inert gas.

b) The location and design of the devices referred to in item a) are to be in accordance with requirements [2.1.1] to [2.1.10].

2.2 **Cargo and slop 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 item a) 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 item b) 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 Ch 1, Sec 12, [4.4.7], item f).

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 (COTVR)

3.1 Application

3.1.1 This Article applies to COTVR systems 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.

3.2 Scope

3.2.1 The limit of the scope of Classification (without PROC notation) is generally downstream the COTVR at the isolation valve referred to in [3.7.4].

3.3 General requirements

3.3.1 The COTVR system is to be designed, constructed and tested to the satisfaction of the Society.

3.3.2 Throughout the present, the term “crude oil tanks” includes also slop tanks and process tanks.

3.3.3 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.

3.3.4 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.

3.3.5 Piping, fittings and mechanical parts of this COTVR system are to comply with the relevant requirements of Part C, Chapter 1.

3.3.6 Equipment must be suitable for the hazardous area where they are located.

3.3.7 The COTVR system is to remain within the cargo area.

3.3.8 Depending on findings of the HAZOP studies, the Society may raise additional requirements.

3.4 Capacity

3.4.1 The system is to be capable of boosting cargo tank vents to the process or LP flare system at a rate of at least 125% of the maximum loading capacity of the unit expressed as a flow rate.

3.5 Materials and constructive measures

3.5.1 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.

3.5.2 Constructive measures are to be taken to minimize the risk of ignition from generation of static electricity by the system itself.

3.6 Particles removal devices

3.6.1 Filters or equivalent devices are to be fitted to minimize the amount of water and other particles carried over to the cargo tanks vents recovery equipment.

3.7 COTVR piping system

3.7.1 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 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 valve 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 case of COTVR is connected to the dirty inert gas header, above referred valves may be the ones of the IG system. Isolation means as per [3.7.3] is nevertheless to be provided.

3.7.2 Piping systems are to be so designed as to prevent the accumulation of cargo or water in the pipelines under all normal conditions.

3.7.3 Arrangements are to be made to ensure an effective isolation of the Vent Recovery Unit from the upstream systems (cargo tanks/cargo venting/inert gas/HC blanket gas systems). This may consist in a shut-down valve.

3.7.4 Arrangements are to be made to ensure an effective isolation of the Vent Recovery Unit from the downstream systems (process systems/LP flare system). This may consist in a shut-down valve.

3.7.5 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.

3.8 Instrumentation

3.8.1 A pressure device to regulate the capacity of the recovery equipment or a gas regulating valve is to be fitted.
3.8.2 Devices and alarms are to be provided for continuously recording and indicating:

a) The temperature and pressure upstream the shutdown valve mentioned in [3.7.3] whenever the system is operating

b) The temperature and pressure upstream the shutdown valve mentioned in [3.7.4]

c) The oxygen content of the gas recovery equipment

d) The failure of the blowers

e) The water level in the devices mentioned in [3.6].

3.8.3 The alarms referred to in [3.8.2] are to be fitted in the cargo central station.

3.9 Safeguards

3.9.1 Automatic stop of the blower as well as closing shutdown valves mentioned in [3.7.3] and [3.7.4] is to be arranged in case of:

- High-high pressure in respect to [3.8.2] item a) and b)
- Low-low pressure in respect to [3.8.2] item a) and b)
- High-high temperature in respect to [3.8.2] item a) and b)
- When content of oxygen exceeds 5% in respect to [3.8.2] item c)
- Failure in respect to [3.8.2] item d)
- High level alarm in respect to [3.8.2] item e).
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 Article [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 Article [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 m 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 m 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 m radius centred upon the centre of the outlet, and within a hemisphere of 6 m radius below the outlet
j) areas on open deck, or semi-enclosed spaces on open deck within 1.5 m of cargo pump room entrances, cargo pump room ventilation inlet, openings into cofferdams or other zone 1 space
k) areas on open deck within 3 m 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 m fore and aft of the forwardmost cargo tank and aft of the aft-most cargo tank bulkhead, up to a height of 2.4 m 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 m surrounding the zone 1 spaces defined in [2.2.3] item h)
b) spaces 4 m beyond the cylinder and 4 m 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 m beyond these up to a height of 2.4 m above the deck
4.2.2 Where the atmosphere in double-hull spaces cannot be reliably measured using flexible gas sampling hoses, such spaces shall be fitted with permanent gas sampling lines. The configuration of gas sampling lines shall be adapted to the design of such spaces.

4.2.3 The materials of construction and dimensions of gas sampling lines shall be such as to prevent restriction. Where plastic materials are used, they shall be electrically conductive.

4.3 Arrangements for fixed hydrocarbon gas detection systems in double-hull and double-bottom spaces of units

4.3.1 In addition to the requirements in [4.1] and [4.2], the units shall be provided with a fixed hydrocarbon gas detection in accordance with Pt C, Ch 4, Sec 5 for measuring hydrocarbon gas concentrations in all ballast tanks and void spaces of double-hull and double-bottom spaces adjacent to the cargo tanks, including the forepeak tank and any other tanks and spaces under the bulkhead deck adjacent to cargo tanks.

Note 1: The term “cargo tanks” in the phrase “spaces adjacent to the cargo tanks” includes slop tanks except those arranged for the storage of oily water only.

Note 2: The term “spaces” in the phrase “spaces under the bulkhead deck adjacent to cargo tanks” includes dry compartments such as ballast pump-rooms and bow thruster rooms and any tanks such as freshwater tanks, but excludes fuel oil tanks.

Note 3: The term “adjacent” in the phrase “adjacent to the cargo tanks” includes ballast tanks, void spaces, other tanks or compartments located below the bulkhead deck adjacent to cargo tanks and includes any spaces or tanks located below the bulkhead deck which form a cruciform (corner to corner) contact with the cargo tanks.

4.3.2 Units provided with constant operative inerting systems for such spaces need not be equipped with fixed hydrocarbon gas detection equipment.

4.3.3 Notwithstanding the above, cargo pump-rooms subject to the provisions of Ch 1, Sec 10, [1.3] need not comply with the requirements of this paragraph.

4.4 Engineering specifications for fixed hydrocarbon gas detection systems in double-hull and double-bottom spaces of units

4.4.1 General

a) The fixed hydrocarbon gas detection system is to be designed, constructed and tested to the satisfaction of the Society based on performance standards developed by IMO (Msc.1 Circ. 1370).

b) The system is to be comprised of a central unit for gas measurement and analysis and gas sampling pipes in all ballast tanks and void spaces of double-hull and double-bottom spaces adjacent to the cargo tanks, including the forepeak tank and any other tanks and spaces under the bulkhead deck adjacent to cargo tanks.
c) The system may be integrated with the cargo pump-room gas detection system, provided that the spaces referred to in item b above are sampled at the rate required in [4.4.2], item c) 1). Continuous sampling from other locations may also be considered provided the sampling rate is complied with.

4.4.2 Component requirements

a) Gas sampling lines

1) Common sampling lines to the detection equipment shall not be fitted, except the lines serving each pair of sampling points as required in item 3) below.

2) The materials of construction and the dimensions of gas sampling lines are to be such as to prevent restriction. Where non-metallic materials are used, they shall be electrically conductive. The gas sampling lines shall not be made of aluminium.

3) The configuration of gas sampling lines is to be adapted to the design and size of each space. Except as provided in items 4) and 5) below, the sampling system shall allow for a minimum of two hydrocarbon gas sampling points, one located on the lower and one on the upper part where sampling is required. When required, the upper gas sampling point shall not be located lower than 1 m from the tank top. The position of the lower located gas sampling point shall be above the height of the girder of bottom shell plating but at least 0,5 m from the bottom of the tank and it shall be provided with means to be closed when clogged. In positioning the fixed sampling points, due regard should also be given to the density of vapours of the oil products intended to be transported and the dilution from space purging or ventilation.

4) For units with deadweight of less than 50000 tonnes, the Society may allow the installation of one sampling location for each tank for practical and/or operational reasons.

5) For ballast tanks in the double-bottom, ballast tanks not intended to be partially filled and void spaces, the upper gas sampling point is not required.

6) Means are to be provided to prevent gas sampling lines from clogging when tanks are ballasted by using compressed air flushing to clean the line after switching from ballast to cargo loaded mode. The system shall have an alarm to indicate if the gas sampling lines are clogged.

b) Gas analysis unit

The gas analysis unit shall be located in a safe space and may be located in areas outside the unit’s cargo area; for example, in the cargo control room and/or navigation bridge in addition to the hydraulic room when mounted on the forward bulkhead, provided the following requirements are observed:

1) Sampling lines shall not run through gas safe spaces, except where permitted under item 5) below

2) The hydrocarbon gas sampling pipes shall be equipped with flame arresters. Sample hydrocarbon gas is to be led to the atmosphere with outlets arranged in a safe location, not close to a source of ignitions and not close to the accommodation area air intakes.

3) Bulkhead penetrations of sample pipes between safe and hazardous areas are to be of a type approved and have same fire integrity as the fire division penetrated. A manual isolating valve, which shall be easily accessible for operation and maintenance, shall be fitted in each of the sampling lines at the bulkhead on the gas safe side.

4) The hydrocarbon gas sampling equipment, including sample piping, sample pumps, solenoids, analysing units etc., shall be located in a reasonably gas-tight cabinet (e.g., fully enclosed steel cabinet with a door with gaskets) which is to be monitored by its own sampling point. At a gas concentration above 30% of the lower flammable limit inside the steel enclosure the entire gas analysing unit is to be automatically shut down; and

5) Where the enclosure cannot be arranged directly on the bulkhead, sample pipes shall be of steel or other equivalent material and without detachable connections, except for the connection points for isolating valves at the bulkhead and analysing unit, and are to be routed on their shortest ways.

c) Gas detection equipment

1) The gas detection equipment is to be designed to sample and analyse from each sampling line of each protected space, sequentially at intervals not exceeding 30 min.

2) Means are to be provided to enable measurements with portable instruments, in case the fixed system is out of order or for system calibration. In case the system is out of order, procedures shall be in place to continue to monitor the atmosphere with portable instruments and to record the measurement results.

3) Audible and visual alarms are to be initiated in the cargo control room, navigation bridge and at the analysing unit when the vapour concentration in a given space reaches a pre-set value, which shall not be higher than the equivalent of 30% of the lower flammable limit.

4) The gas detection equipment shall be so designed that it may readily be tested and calibrated.

5 Electrical installations

5.1 General

5.1.1 Electrical installations for production, storage and offloading surface units are to comply with Part C, Chapter 2 and Part C, Chapter 3.
6 Machinery

6.1 General

6.1.1 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].

7 Fire protection

7.1 General

7.1.1 Particular provisions of the present Article are in addition to the provision of Part C which remains applicable, except otherwise justified.

7.1.2 The fire protection of the storage area is to be provided by a fixed foam fire extinguishing system complying with [7.5].

7.1.3 For units fitted with bow or stern cargo transfer installations, refer to [7.2.5] and Ch 1, Sec 12, [7] for the protection of the corresponding zones.

7.2 Passive fire protection

7.2.1 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 rooms: are spaces containing cargo pumps and entrances and trunks to such spaces

7.2.2 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.

.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.

7.2.6 The location and arrangement of the galleys are to be such that there is a minimum risk of fire.

7.2.7 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 [7.2.2].

7.3 Fire water pumps

7.3.1 The requirements of Pt C, Ch 4, Sec 6 relative to fire water pumps and mains are applicable, together with additional requirements of [7.3.2] and [7.3.3].

7.3.2 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.

7.3.3 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.
Table 1: Fire integrity of bulkheads separating adjacent spaces

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<th>Spaces</th>
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<td>A-0</td>
<td>A-0</td>
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<td></td>
<td>A-0</td>
<td></td>
<td>C</td>
<td>A-60</td>
</tr>
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<tr>
<td>(b)</td>
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<td>A-0</td>
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<td>(10)</td>
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<tr>
<td>Sanitary and similar spaces</td>
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<td></td>
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<td></td>
<td>C</td>
<td>A-60</td>
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<tr>
<td>Cargo pump room</td>
<td>(12)</td>
<td></td>
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</tr>
</tbody>
</table>

[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.

[e]: An engineering evaluation is to be conducted in accordance with Pt C, Ch 4, Sec 4, [4.1.1]. In no case the bulkhead or deck rating is to be less than the value indicated in the tables. See Part C, Chapter 4.

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.

### 7.4 Cargo pump rooms

#### 7.4.1 Each cargo pump room is to be provided with a fixed fire extinguishing system operated from a readily accessible position outside the pump room.

#### 7.4.2 The fixed fire extinguishing system required in [7.4.1] 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:

- either a carbon dioxide or another extinguishing medium system complying with the applicable provisions of Pt C, Ch 4, Sec 11, [4.1.1] and with the following:
  - the audible signal mentioned in Pt C, Ch 4, Sec 11, [4.1.1] item b2), 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].
### Table 2: Fire integrity of decks separating adjacent spaces

<table>
<thead>
<tr>
<th>Spaces below</th>
<th>Space above</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control stations</td>
<td>(1) A-0 A-0 A-0 A-0 A-0 A-60 A-0 [e] A-0 * A-0 XXX</td>
</tr>
<tr>
<td>Corridors</td>
<td>(2) A-0 * * A-0 * A-60 A-0 A-0 [e] A-0 * * XXX</td>
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<td>Accommodation</td>
<td>(3) A-60 A-0 * A-0 * A-60 A-0 A-0 [e] A-0 * * XXX</td>
</tr>
<tr>
<td>Stairways</td>
<td>(4) A-0 A-0 A-0 * A-0 A-60 A-0 A-0 [e] A-0 * A-0 XXX</td>
</tr>
<tr>
<td>Service spaces</td>
<td>(5) A-15 A-0 A-0 A-0 * A-60 A-0 A-0 A-0 * A-0 XXX</td>
</tr>
<tr>
<td>Machinery spaces</td>
<td>(6) A-60 A-60 A-60 A-60 A-0 [a] A-60 A-60 A-60 * A-0 XXX</td>
</tr>
<tr>
<td>Other machinery</td>
<td>(7) A-15 A-0 A-0 A-0 A-0 A-60 A-0 A-0 * A-0 XXX</td>
</tr>
<tr>
<td>Service spaces</td>
<td>(9) A-60 A-0 A-0 A-0 A-0 A-0 A-60 A-0 A-0 A-0 [c] * A-0 XXX</td>
</tr>
<tr>
<td>Open decks</td>
<td>(10) * * * * * * * – * – * XXX</td>
</tr>
<tr>
<td>Sanitary and</td>
<td>(11) A-0 A-0 A-0 A-0 A-0 A-0 A-0 A-0 * * XXX</td>
</tr>
<tr>
<td>similar spaces</td>
<td>Cargo pump room</td>
</tr>
</tbody>
</table>

**Note 1:** Refer to Tab 1
**Note 2:** "XXX" in the cells indicates that corresponding vicinities are prohibited.

### 7.4.3 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.

### 7.4.4 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.

### 7.5 Fixed deck foam system

#### 7.5.1 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.

#### 7.5.2 Principles

a) The arrangements for providing foam are to be capable of delivering foam to the entire cargo tank deck area as well as into any cargo tank the deck of which 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 output shall permit the simultaneous use of the minimum required number of jets of water at the required pressure from the fire main. Where the deck foam system is supplied by a common line from the fire main, additional foam concentrate shall be provided for operation of two nozzles for the same period of time required for the foam system.

The simultaneous use of the minimum required jets of water shall be possible on deck over the full length of the ship, in the accommodation spaces, service spaces, control stations and machinery spaces.

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.

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.
7.5.3 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), whichever is the greatest.

c) When medium expansion ratio foam (between 21 to 1 and 200 to 1 expansion ratio) is employed, the application rate of the foam and the capacity of a monitor installation shall 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 supplied on board shall be approved by the Society (Refer to the Guidelines for performance and testing criteria and surveys of foam concentrates for fixed fire-extinguishing systems (MSC.1/Circ.1312)) for the cargoes intended to be carried. Type B foam concentrates shall be supplied for the protection of crude oil, petroleum products and non-polar solvent cargoes. Type A foam concentrates shall be supplied for polar solvent cargoes. Type A foam concentrates shall be approved by the Society.

f) Liquid cargoes with a flashpoint not exceeding 60°C for which a regular foam fire-fighting system is not effective shall comply with the provisions of regulation II-2/1.6.2.1 of the SOLAS Convention.

7.5.4 Monitors, nozzles of deluge systems and applicators

a) 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.

b) When an arrangement of monitor is provided, 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) The capacity of the deluge system is to be compliant with [7.5.3]item a(3).

e) Foam applicators, nozzles and monitors are to be of type approved by the Society.

f) Prototype tests of the monitors, nozzles and foam applicators shall be performed to ensure the foam expansion and drainage time of the foam produced does not differ more than ± 10 per cent of that determined in [7.5.3], item d).

7.5.5 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 [7.5.2] 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. The monitors and hose connections shall be at least of any cargo tanks, may be located in the cargo area above pump-rooms, cofferdams, ballast tanks and void spaces adjacent to cargo tanks if capable of protecting the deck below and aft of each other.

   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 [7.5.2].
   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 [7.5.3] item a(3). See Ch 1, Sec 10, [1.7].

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.

7.6 Emergency and offloading control station

7.6.1 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.

7.6.2 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.

8 Life saving appliances

8.1 Life saving appliances

8.1.1 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.

9 Temporary refuge

9.1 General

9.1.1 Temporary refuge is a facility where the personnel can muster temporarily and prepare for the evacuation of the unit. The emergency response is to be communicated and controlled from the temporary refuge.

9.1.2 At least one main temporary refuge is to be fitted onboard the unit. Depending on the unit dimensions and arrangements of means of escape, the Society may require a secondary refuge.

9.1.3 The main temporary refuge is to be located in the accommodation area, being generally a part of the living quarters. The whole accommodation building may be designed as temporary refuge.

9.1.4 The main temporary refuge is to include the following facilities:

- main muster area
- standby control room
- emergency response centre.

9.1.5 At least two separate means of escape are to be provided to evacuate from the temporary refuge to the deck level and to the helideck. One of these means of escape may be an emergency escape door, to be used only in the case of emergency.

9.1.6 All the doors used for the normal access to the spaces in the main temporary refuge are to be equipped with positive pressurised air locks.

9.1.7 When a secondary refuge is fitted, suitable means of communication with the main temporary refuge are to be provided.
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 NR459, 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 lead through cargo tanks, slop tanks or process 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, slop tanks or process 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 suction, 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 Ballast tanks within the cargo area

2.3.1 Tanks within cargo area, intended to be used exclusively for ballast, are, according to [2.1.3] and unless otherwise permitted, to be served by piping and pumping systems independent of cargo and fuel oil piping and pumping systems. Ballast systems serving 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 item a) 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 item a) 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], item 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 areas 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 Fore peak ballast system

2.6.1 The fore peak can be ballasted with the system serving ballast tanks within the storage area, provided:

(a) the tank is considered as hazardous

(b) the vent pipe openings are located on open deck 3 m away from sources of ignition

(c) means are provided, on the open deck, to allow measurement of flammable gas concentrations within the tank by a suitable portable instrument

(d) the access to the fore peak tank is direct from open deck. Alternatively, indirect access from the open deck to the fore peak tank through an enclosed space may be accepted provided that:

- in case the enclosed space is separated from the cargo tanks by cofferdams, the access is through a gas tight bolted manhole located in the enclosed space and a warning sign is to be provided at the manhole stating that the fore peak tank may only be opened after:
  - it has been proven to be gas free, or
  - any electrical equipment which is not certified safe in the enclosed space is isolated

- in case the enclosed space has a common boundary with the cargo tanks and is therefore hazardous, the enclosed space can be well ventilated.

2.7 Carriage of ballast in cargo tanks

2.7.1 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.

2.7.2 Two shut-off valves, at least, are recommended to isolate cargo piping system from sea chests.

2.7.3 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.

2.7.4 Provisions are to be made, to the Society’s satisfaction, to permit efficient draining of tanks at the end of offloading.

2.7.5 The cargo piping system is to be so designed and arranged as to permit efficient cleaning and draining.

2.7.6 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].

2.7.7 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.

2.8 Scupper lines

2.8.1 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.

2.8.2 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.
Table 1: Monitoring of cargo pumps

<table>
<thead>
<tr>
<th>Equipment, parameter</th>
<th>Alarm (1)</th>
<th>Indication (1)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump, discharge pressure</td>
<td></td>
<td>L</td>
<td>• on the pump (2), or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• next to the unloading control station</td>
</tr>
<tr>
<td>Pump casing, temperature</td>
<td>H</td>
<td>visual and audible, in cargo control room or pump control station</td>
<td></td>
</tr>
<tr>
<td>Bearings, temperature</td>
<td>H</td>
<td>visual and audible, in cargo control room or pump control station</td>
<td></td>
</tr>
<tr>
<td>Bulkhead shaft gland, temperature, if relevant</td>
<td>H</td>
<td>visual and audible, in cargo control room or pump control station</td>
<td></td>
</tr>
</tbody>
</table>

(1) H = high, L = low
(2) and next to the driving machine if located in a separate compartment.

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.

c) Cargo pumps may be used, where necessary, for the washing of cargo tanks.

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
   3) electric motors of a certified safe type suitable for installation in hazardous area zone 1 as specified in Ch 1, Sec 11, [2.2] with explosion group and temperature class of at least II A and T3 as per Pt C, Ch 2, Sec 15, [4].

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] are 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

Cargo piping is to be designed and constructed according to the requirements of Pt C, Ch 1, Sec 7.

Cargo piping conveying liquids are to comply with the requirements applicable to piping class I, unless otherwise agreed with the Society.

Cargo piping conveying gases are to comply with the requirements applicable to the following piping classes, unless otherwise agreed with the Society:
   • Class I, when \( p > 1.6 \, \text{MPa} \) or \( T > 200 \, ^\circ\text{C} \)
   • Class II, otherwise.
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 Ch 1, Sec 6 are provided, the ohm electrical resistance of cargo hoses is not to exceed $10^6 \Omega$.

3.4 Cargo piping arrangement and installation

3.4.1 Cargo pipes passing through tanks or compartments

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 [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 8000 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 unloading and necessary in-tank operations, and
- 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.

Units required to be provided with an inert gas system by item a) or b) are to receive the class notation INERTGAS.

4.1.2 Units where an inert gas system is not required but provided with the class notation INERTGAS

Inert gas systems provided on units where such systems are not required by [4.1.1] and which are provided with the class notation INERTGAS are to comply with the provisions of [4.6].

4.2 Definitions

4.2.1 For the purposes of this Article:

a) Cargo tanks means those cargo tanks, including slop tanks, which carry cargoes, or cargo residues, having a flashpoint not exceeding 60ºC.

b) Inert gas system includes inert gas systems using flue gases, inert gas generators, and nitrogen generators and means the inert gas plant and inert gas distribution together with means for preventing backflow of cargo gases to machinery spaces, fixed and portable measuring instruments and control devices.

c) Gas-safe space is a space in which the entry of gases would produce hazards with regard to flammability or toxicity.

d) Gas-free is a condition in a tank where the content of hydrocarbon or other flammable vapour is less than 1% of the lower flammable limit (LFL), the oxygen content is at least 21%, and no toxic gases are present.

Note 1: Refer to the Revised recommendations for entering enclosed spaces aboard ships (IMO resolution A.1050(27)).

4.3 Requirements for all systems

4.3.1 General

a) The inert gas systems shall be designed, constructed and tested to the satisfaction of the Society. It shall be designed to be capable of rendering and maintaining the atmosphere of the relevant cargo tanks non-flammable.

Note 1: Refer to the Revised standards for the design, testing and locating of devices to prevent the passage of flame into cargo tanks in tankers (MSC/Circ.677, as amended by MSC/Circ.1009 and MSC.1/Circ.1324) and the Revised factors to be taken into consideration when designing cargo tank venting and gas-freeing arrangements (MSC/Circ.731).

b) The system shall be capable of:

1) inverting empty cargo tanks and maintaining the atmosphere in any part of the tank with an oxygen content not exceeding 8% by volume and at a positive pressure in port and at sea except when it is necessary for such a tank to be gas-free;

2) 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;

3) purging empty cargo tanks of hydrocarbon or other flammable vapours, so that subsequent gas-freeing operations will at no time create a flammable atmosphere within the tank;

4) delivering inert gas to the cargo tanks at a rate of at least 125% of the maximum rate of discharge capacity of the ship expressed as a volume, and
5) delivering inert gas with an oxygen content of not more than 5% by volume to the cargo tanks at any required rate of flow.

c) Materials used in inert gas systems shall be suitable for their intended purpose. In particular, those components 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.

d) The inert gas supply may be:
   1) treated flue gas from main or auxiliary boilers, or
   2) gas from an oil or gas-fired gas generator, or
   3) gas from nitrogen generators.

The Society may accept systems using inert gases from one or more separate gas generators or other sources or any combination thereof, provided that an equivalent level of safety is achieved. Such systems shall, as far as practicable, comply with the requirements of this article. Systems using stored carbon dioxide shall not be permitted unless the Administration is satisfied that the risk of ignition from generation of static electricity by the system itself is minimized.

4.3.2 Safety measures

a) The inert gas system shall 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.

b) Automatic shutdown of the inert gas system and its components parts shall be arranged on predetermined limits being reached, taking into account the provisions of [4.3.4], [4.4.3] and [4.5.14].

c) Suitable shutoff arrangements shall be provided on the discharge outlet of each generator plant.

d) The system shall be designed to ensure that if the oxygen content exceeds 5% by volume, the inert gas shall be automatically vented to atmosphere.

e) Arrangements shall be provided to enable the functioning of the inert gas plant to be stabilized before commencing cargo discharge. If blowers are to be used for gas-freeing, their air inlets shall be provided with blanking arrangements.

f) Where a double block and bleed valve is installed, the system shall ensure upon of being separated from the inert gas main by:

• 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; and

• 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.

3) The second non-return device shall be a non-return valve or equivalent capable of preventing the return of vapours and liquids and fitted between the deck water seal (or equivalent device) and the first connection from the inert gas main to a cargo tank. It shall 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 between the non-return valve and the first connection to the cargo tanks to isolate the deck water seal, or equivalent device, from the inert gas main to the cargo tanks.

4) A water seal, if fitted, shall be capable of being supplied by two separate pumps, each of which shall be capable of maintaining an adequate supply at all times. The audible and visual alarm on the low level of water in the water seal shall operate at all times.

5) The arrangement of the water seal, or equivalent devices, and its associated fittings shall be such that it will prevent backflow of vapours and liquids and will ensure the proper functioning of the seal under operating conditions.

6) Provision shall 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.

7) A water loop or other approved arrangement shall also be fitted to each associated water supply and drain pipe and each venting or pressure-sensing pipe leading to gas-safe spaces. Means shall be provided to prevent such loops from being emptied by vacuum.

8) Any water seal, or equivalent device, and loop arrangements shall be capable of preventing return of vapours and liquids to an inert gas plant at a pressure equal to the test pressure of the cargo tanks.

9) The non-return devices shall be located in the cargo area on deck.

b) Inert gas lines

1) The inert gas main may be divided into two or more branches forward of the non-return devices required by item a).

2) The inert gas main shall be fitted with branch piping leading to the cargo tank. Branch piping for inert gas shall be fitted with either stop valves or equivalent means of control for isolating each tank. Where stop valves are fitted, they shall be provided with locking arrangements. The control system shall provide unambiguous information of the operational status of such valves to at least the control panel required in [4.3.4].

3) Each cargo tank not being inerted shall be capable of being separated from the inert gas main by:

• removing spool-pieces, valves or other pipe sections, and blanking the pipe ends; or

• arrangement of two spectacle flanges in series with provisions for detecting leakage into the pipe between the two spectacle flanges; or
4) Means shall be provided to protect cargo tanks against the effect of overpressure or vacuum caused by thermal variations and/or cargo operations when the cargo tanks are isolated from the inert gas mains.

5) Piping systems shall be so designed as to prevent the accumulation of cargo or water in the pipelines under all normal conditions.

6) Arrangements shall be provided to enable the inert gas main to be connected to an external supply of inert gas. The arrangements shall consist of a 250 mm nominal pipe size bolted flange, isolated from the inert gas main by a valve and located forward of the non-return valve. The design of the flange should conform to the appropriate class in the standards adopted for the design of other external connections in the ship’s cargo piping system.

7) If a connection is fitted between the inert gas main and the cargo piping system, arrangements shall be made to ensure an effective isolation having regard to the large pressure difference which may exist between the systems. This shall 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.

8) The valve separating the inert gas main from the cargo main and which is on the cargo main side shall be a non-return valve with a positive means of closure (see Fig 2).

9) Inert gas piping systems shall not pass through accommodation, service and control station spaces.

Figure 2: Effective isolation between cargo and inert gas piping

4.3.4 Indicators and alarms

a) The operation status of the inert gas system shall be indicated in a control panel.

b) Instrumentation shall be fitted for continuously indicating and permanently recording, when inert gas is being supplied:

1) the pressure of the inert gas mains forward of the non-return devices; and

2) the oxygen content of the inert gas.

c) The indicating and recording devices shall be placed in the cargo control room where provided. But where no cargo control room is provided, they shall be placed in a position easily accessible to the officer in charge of cargo operations.

d) In addition, meters shall be fitted:

1) in the central control station, and navigating bridge if any, to indicate at all times the pressure referred to in item b) 1); and

2) in the machinery control room or in the machinery space to indicate the oxygen content referred to in item b) 2).

e) Audible and visual alarms

1) Audible and visual alarms shall be provided, based on the system designed, to indicate:

- oxygen content in excess of 5% by volume (see also item e) 2));
- failure of the power supply to the indicating devices as referred to in item b);
- gas pressure less than 100 mm water gauge (see also item e) 2));
- high-gas pressure; and
- failure of the power supply to the automatic control system (see also item e) 2)).

2) The alarms required in item e) 1) for:

- oxygen content
- gas pressure less than 100 mm water gauge, and
- failure of the power supply to the automatic control system,

shall 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) An audible alarm system independent of that required in item e) 1) for gas pressure less than 100 mm water gauge, or automatic shutdown of cargo pumps shall be provided to operate on predetermined limits of low pressure in the inert gas main being reached.

4) Two oxygen sensors shall be positioned at appropriate locations in the space or spaces containing the inert gas system. If the oxygen level falls below 19%, these sensors shall trigger alarms, which shall be both visible and audible inside and outside the space or spaces and shall be placed in such a position that they are immediately received by responsible members of the crew.

4.3.5 Instruction manuals

Detailed instruction manuals shall 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.

Note 1: Refer to the Revised Guidelines for inert gas systems (MSC/Circ.353), as amended by MSC/Circ.387.

The manuals shall include guidance on procedures to be followed in the event of a fault or failure of the inert gas system.
4.4 Requirements for flue gas and inert gas generator systems

4.4.1 Application
In addition to the provisions in [4.3], for inert gas systems using flue gas or inert gas generators, the provisions of this sub-article shall apply.

4.4.2 System requirements
a) Inert gas generators
1) Two fuel oil pumps shall be fitted to the inert gas generator. Suitable fuel in sufficient quantity shall be provided for the inert gas generators.
2) The inert gas generators shall be located outside the cargo tank area. Spaces containing inert gas generators shall have no direct access to accommodation service or control station spaces, but may be located in machinery spaces. If they are not located in machinery spaces, such a compartment shall be separated by a gastight steel bulkhead and/or deck from accommodation, service and control station spaces. Adequate positive-pressure-type mechanical ventilation shall be provided for such a compartment.

b) Gas regulating valves
1) A gas regulating valve shall be fitted in the inert gas main. This valve shall be automatically controlled to close, as required in [4.3.2], item b). It shall also be capable of automatically regulating the flow of inert gas to the cargo tanks unless means are provided to automatically control the inert gas flow rate.
2) The gas regulating valve shall be located at the forward bulkhead of the forward most gas-safe space through which the inert gas main passes.

c) Cooling and scrubbing arrangement
1) Means shall be fitted which will effectively cool the volume of gas specified in [4.3.1], item b) and remove solids and sulphur combustion products. The cooling water arrangements shall be such that an adequate supply of water will always be available without interfering with any essential services on the ship. Provision shall also be made for an alternative supply of cooling water.
2) Filters or equivalent devices shall be fitted to minimize the amount of water carried over to the inert gas blowers.

d) Blowers
1) At least two inert gas blowers shall be fitted and be capable of delivering to the cargo tanks at least the volume of gas required by [4.3.1], item b). For systems fitted with inert gas generators the Society may permit only one blower if that system is capable of delivering the total volume of gas required by [4.3.1], item b) to the 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 ship’s crew.
2) Where inert gas generators are served by positive displacement blowers, a pressure relief device shall be provided to prevent excess pressure being developed on the discharge side of the blower.
3) When two blowers are provided, the total required capacity of the inert gas system shall be divided evenly between the two and in no case is one blower to have a capacity less than 1/3 of the total required.

e) Inert gas isolating valves
For systems using flue gas, flue gas isolating valves shall be fitted in the inert gas mains between the boiler uptakes and the flue gas scrubber. These valves shall be provided with indicators to show whether they are open or shut, and precautions shall be taken to maintain them gastight and keep the seatings clear of soot. Arrangements shall be made to ensure that boiler soot blowers cannot be operated when the corresponding flue gas valve is open.
f) Prevention of flue gas leakage
1) Special consideration shall be given to the design and location of scrubber and blowers with relevant piped and fittings in order to prevent flue gas leakages into enclosed spaces.
2) To permit safe maintenance, an additional water seal or other effective means of preventing flue gas leakage shall be fitted between the flue gas isolating valves and scrubber or incorporated in the gas entry to the scrubber.

4.4.3 Indicators and alarms
a) In addition to the requirements in [4.3.4], item b), means shall be provided for continuously indicating the temperature of the inert gas at the discharge side of the system, whenever it is operating.
b) In addition to the requirements in [4.3.4], item e), audible and visual alarms shall be provided to indicate:
   • insufficient fuel oil supply to the oil-fired inert gas generator;
   • failure of the power supply to the generator;
   • low water pressure or low water flow rate to the cooling and scrubbing arrangement;
   • high water level in the cooling and scrubbing arrangement;
   • high gas temperature;
   • failure of the inert gas blowers; and
   • low water level in the water seal.

4.5 Requirements for nitrogen generator systems when inert gas is required

4.5.1 The following requirements apply where a nitrogen generator system is fitted on board as required by [4.1.1]. For the purpose, the inert gas is to be produced by separating air into its component gases by passing compressed air through a bundle of hollow fibres, semi-permeable membranes or adsorber materials.
4.5.2 In addition to the provisions in [4.3], for inert gas systems using nitrogen generators, the provisions of the present Article apply.

4.5.3 The nitrogen generator system is to comply with Ch 1, Sec 10, [2.2.2] and Ch 1, Sec 10, [2.1.11].

4.5.4 A nitrogen generator is to consist of a feed air treatment system and any number of membrane or adsorber modules in parallel necessary to meet the requirements of [4.3.1], item b) 4).

4.5.5 The nitrogen generator is to be capable of delivering high purity nitrogen in accordance with, item b) 5). In addition to, item d), the system is to be fitted with automatic means to discharge “off-spec” gas to the atmosphere during start-up and abnormal operation.

4.5.6 The system shall be provided with one or more compressors to generate enough positive pressure to be capable of delivering the total volume of gas required by [4.3.1], item b).

4.5.7 Where two compressors are provided, 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.

4.5.8 A feed air treatment system shall be fitted to remove free water, particles and traces of oil from the compressed air.

4.5.9 It is also to preserve the specification temperature.

4.5.10 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.

Note 1: “safe location” needs to address the two types of discharges separately:
- oxygen-enriched air from the nitrogen generator - safe locations on the open deck are:
  - outside of hazardous area;
  - not within 3m of areas traversed by personnel; and
  - not within 6m of air intakes for machinery (engines and boilers) and all ventilation inlets
- nitrogen-product enriched gas from the protective devices of the nitrogen receiver - safe locations on the open deck are:
  - not within 3m of areas traversed by personnel; and
  - not within 6m of air intakes for machinery (engines and boilers) and all ventilation inlets/outlets.

4.5.11 In order to permit maintenance, means of isolation are to be fitted between the generator and the receiver.

4.5.12 The air compressor and nitrogen generator may be installed in the engine-room or in a separate compartment. A separate compartment and any installed equipment shall be treated as an “Other machinery space” with respect to fire protection. Where a separate compartment is provided for the nitrogen generator, the compartment shall be fitted with an independent mechanical extraction ventilation system providing six air changes per hour. The compartment is to have no direct access to accommodation spaces, service spaces and control stations.

4.5.13 Where a nitrogen receiver or a buffer tank is installed, it may be installed in a dedicated compartment, in a separate compartment containing the air compressor and the generator, in the engine room, or in the cargo area. Where the nitrogen receiver or a buffer tank is installed in an enclosed space, the access shall be arranged only from the open deck and the access door shall open outwards. Adequate, independent mechanical ventilation, of the extraction type, shall be provided for such a compartment.

4.5.14 Indicators and alarms
a) In addition to the requirements in [4.3.4], item b), instrumentation is to be provided for continuously indicating the temperature and pressure of air at the suction side of the nitrogen generator.
b) In addition to the requirements in [4.3.4], item e), audible and visual alarms shall be provided to include:
- failure of the electric heater, if fitted;
- low feed-air pressure or flow from the compressor;
- high-air temperature; and
- high condensate level at automatic drain of water separator.

4.6 Requirements for nitrogen generator / inert gas system when fitted but not required

4.6.1 Nitrogen/inert gas systems fitted on units for which an inert gas system is not required are to comply with the following requirements.

4.6.2 Requirements of:
- [4.3.2], item b)
- [4.3.2], item d)
- [4.3.4], item b)
- [4.3.4], item c)
- [4.3.4], item e) 1) regarding oxygen content and power supply to the indicating devices
- [4.3.4], item e) 4)
- [4.5.6], [4.5.8], [4.5.12], [4.5.13] and [4.5.14]
apply to the systems.
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 [3.3.1] 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, [3.2.1].

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 and 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 shut-down 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, [3.8.2] 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) oxygen content in each individual cargo tank protected by the hydrocarbon blanket gas system.

Note 1: The oxygen analysis continuously performed on a tank by tank sequential basis is acceptable.

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, [3.9] 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), 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, [3.8.2] item e) (failure of the recovery equipment).

Note 1: These requirements 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.

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 in 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 Cathodic protection

6.6.3 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.

6.6.4 In all cases, the anodes are to be properly secured to the structure.

6.6.5 As a general rule, the requirements of the present [6.6] are applicable also to compartments adjacent to cargo or slop tanks.

6.7 Aluminium paints

6.7.1 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, [7.2.5].
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, [7.5], 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, [7.5] 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 NR481, Design and Installation of Dual Fuel Engines Using Low Pressure Gas
- Pt C, Ch 1, App 1, which addresses the design of dual fuel engines supplied by high pressure gas
- Pt C, Ch 1, App 5, which addresses the design of dual fuel engines supplied by low pressure gas and dual fuel gas turbines

1.3  Documents to be submitted

1.3.1  The drawings and documents to be submitted for gas fuelled installations are listed in NR481, 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  Combustible 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. Hydrogen sulphide detectors are also to be fitted unless means for sulphur removal are provided. The gas detection systems is to comply with the requirement of Pt C, Ch 4, Sec 5, [4].
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.

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>
<thead>
<tr>
<th>Working pressure (bar)</th>
<th>Nature of the gas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lighter than air</td>
</tr>
<tr>
<td>≤10</td>
<td>double-walled piping according to [3.2.2], or</td>
</tr>
<tr>
<td></td>
<td>safeguarded machinery spaces according to [3.2.3] (1)</td>
</tr>
<tr>
<td>&gt;10</td>
<td>double-walled piping according to [3.2.2]</td>
</tr>
</tbody>
</table>

(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 per hour. The ventilation system should be arranged to maintain 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 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>
<thead>
<tr>
<th>Gas piping type</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double wall type with pressurized and inerted external pipe (see [3.2.2], item a1))</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>- internal pipe</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- external pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double wall type with inerted external pipe or duct (see [3.2.2], item a2))</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>- internal pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- external pipe or duct</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas pipe arranged according to the “safeguarded machinery space” (see [3.2.3])</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Open-ended gas vent lines</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
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 radiographed.

b) Class II pipes

Class II pipes may be connected as required in item a) 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 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 shut-off 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 gas composition within the unit specification range, 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 Ch 1, Sec 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>
<thead>
<tr>
<th>External diameter de of pipe, in mm</th>
<th>Minimum thickness t, in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>de ≤ 82,5</td>
<td>6,3</td>
</tr>
<tr>
<td>88,9 &lt; de ≤ 108,0</td>
<td>7,1</td>
</tr>
<tr>
<td>114,3 &lt; de ≤ 139,7</td>
<td>8,0</td>
</tr>
<tr>
<td>152,4 &lt; de</td>
<td>8,8</td>
</tr>
</tbody>
</table>

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 are to be 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 of 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 IACS UR 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 Pt C, Ch 2, Sec 10.

1.4.2 Dynamic tests

A continuity test is to be performed with the swivel in rotation.

2 Marine riser 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 are to be specified on the Certificate of Classification.

The provisions of the present Article [2] are only applicable to marine riser systems connecting production or storage units to sea-bottom equipment and export lines when the additional class notation RIPRO 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 to 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”

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 NR493, Classification of Mooring Systems for Permanent Offshore Units.